WADD TECHNICAL REPORT 60-42 AD-A280 890 Box - 597 56-8-34 SOME QUANTITATIVE ASPECTS OF **FATIGUE OF MATERIALS** DTIC WUDGEL A SEVEN SUCCESSION & Harold N. Cummings Curtiss-Wright Corporation, Propeller Division Caldwell, New Jersey (C) TI) (1) JULY 1960 3 WRIGHT AIR DEVELOPMENT DIVISION

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SOME QUANTITATIVE ASPECTS OF FATIGUE OF MATERIALS

Harold N. Cummings

Curtiss-Wright Corporation, Propeller Division Caldwell, New Jersey

JULY 1960

Materials Central Contract AF33(616)-6552 Project No. 7381

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WRIGHT AIR DEVELOPMENT DIVISION
AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE
WRIGHT-PATTERSON AIR FORCE BASE, OHIO

FOREWORD

This report was prepared by Curtiss-Wright Corporation, Propeller Division, under USAF Contract No. AF 33(616)-6552. This contract was initiated under Project No. 7381, "Materials Applications", Task No. 73810, "Exploratory Design and Prototype Development." The work was administered under the direction of the Materials Central, Directorate of Advanced Systems Technology, Wright Air Development Division, with Mr. K. D. Shimmin acting as project engineer.

This report covers work conducted from May 1959 to April 1960.

The interest and suggestions of Messrs. J. M. Mergen, Director of Engineering, F. B. Stulen, Assistant Chief Engineer, Analysis, and W. C. Schulte, Chief Metallurgist, at Curtiss-Wright Corporation, Propeller Division, are gratefully acknowledged.

ABSTRACT

In this report are given not only the fatigue properties of many structural materials but also the "static" properties and such other supplementary information as was given in the references consulted. The data are in general from room temperature tests, but a few data are given on tests at higher temperatures. The data are presented in tables and on curves, supplemented by brief discussions in the text.

PUBLICATION REVIEW

This report has been reviewed and is approved.

FOR THE COMMANDER:

W. J. TRAPP Chief, Strength and Dynamics Branch

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Materials Central

PABLE OF CONTENTS

SECTION	PA	GE
I	Introduction	1
	1.2 The Format of This Report	1 1 1
II	Steels	2
	2.1 General	5 5
	2.2.3 SAE Steels 52100 to 98B40	2 4 7 9
III	Heat Resistant Alloys	0
	3.1 General	0
IV	Aluminum Alloys	4
	4.1 General	4 4
	4.2.1 Aluminum Alloy 2014 (148)	4668
V	Magnesium Alloys	9
	5.1 General	9
VI	Titanium Alloys	1
	6.1 General	1
AII	Miscellaneous Materials	4
	7.1 General	4 4
	Bibliography	8
	List of Authors of References	4
	Tiet of Metamials	6

LIST OF TABLES

TABLE	PAG	E
I	SAE Steels 1008 to 4335	,
II	SAE Steels 4340 to 4350	ı
III	SAE Steels 52100 to 98B40 54	
IA	Special Steels	
•	Heat Resistant Alloys	,
AI	Aluminum Alloy 2014 (148)	,
VII	Aluminum Alloy 2024 (24S)	
VIII	Aluminum Alloy 6061 (618)	,
IX	Aluminum Alloy 7075 (758))
x	Aluminum Alloy 7076 (768)	,
XI	Aluminum Alloy 7079	}
XII	Magnesium Alloys)
XIII	Titanium Alloys	1
XIA	Miscellaneous Materials	ļ
PTOWNO	LIST OF ILLUSTRATIONS	
PIGURE	PAG	_
1	Fatigue Strength of Steels vs. Ultimate Tensile Strength 138	,
2	S-N Curves for SAE 1008 Steel, Decarburized and Not Decarburized)
3	S-N Curves for 1020 Steel)
4	S-N Curves for 1040 Wrought Steel, Annealed, 81.4 ksi UTS 143	L
5	S-N Curves for 1040 Wrought Steel, Normalized and Tempered, 90 ksi UTS	L
6	S-N Curves for 1040 Cast Steel, Annealed, 83.5 ksi UTS 142	?
7	S-N Curves for 1040 Cast Steel, Normalized and Tempered, 94.2 km1 UTS	<u>}</u>
8	S-N Curves - Carburized 2315 Steel, Smooth	3

TOURS	P	AGE
9	Design of Notch Used for Fatigue Tests of Carburized Steels	44
10	S-N Curves - Notched 2315 Carburized Steel	44
11	S-N Curves - Smooth 2330 Carburized Steel	145
12	S-N Curves - Notched 2330 Carburized Steel	145
13	S-N Curve for SAE 2340 Steel, Notched	146
14	Approximate S-N Curves for Normalized 4130 Steel. Fully Reversed Axial Stresses	147
15	Alternating vs. Mean Stress, for Normalized 4130 Steel. Axial Stresses	148
16	S-N Curves - Steel SAE 4320 - "Transverse" Specimens	149
17	S-N Curves for V-Modified 4330 Steel, 263 ksi UTS	150
18	S-N Curves for V-Modified 4330 Steel, 250 ks1 UTS	150
19	S-N Curve for Smooth V-Modified 4330 Steel, 236 kmi UTS	150
20	S-N Curve for Smooth V-Modified 4330 Steel, 222 kmi UTS	151
21	S-N Curve for V-Modified 4330 Steel, 201 kmi UTS	151
22	Statistical Variation in Fatigue Life and Endurance Limit for Quenched and Tempered SAE 4340	152
23	Statistical Variation in Fatigue Life and Endurance Limit of Quenched and Spheriodized SAE 4340	152
24	S-N Curves for SAE 4340 Steel, UTS 164 ksi	153
25	S-N Curves, for Fully Reversed Axial Stress, of SAE 4340 Steel]	154
26	S-N Curves; SAE 4340 Steel. Low RAT	155
27	S-N Curves; SAE 4340 Steel. High RAT	155
28	"Fully Reversed" S-N Curves for SAE 4340 Steel - Room Temp]	156
29	S-N Curves for SAE 4340 Steel - Room Temp With Steady Stress]	156
30	Alternating Stress - Steady Stress Diagrams for Different Lifetimes. SAE 4340 Steel, of 158.5 ksi UTS. Axial Tests]	57
31	S-N Curves for SAE 4340 Steel, UTS 150 kmi	.58
32	S-N Curves for SAE 4340 Steel	.59
33	Mean Endurance Limit vs. UTS of SAE 4340 Steel	.60
34	S-N Curves for SAE 4340 Steel, 172 km1 UTS, Tested in Bending]	61

PIGURE		PAGE
35	S-N Curves for SAE 4340 Steel, 172 ks1 UTS, Tested in Torsion .	161
36	Alternating vs. Steady Bending Stresses for SAE 4340 Steel, 172 ksi UTS	162
37	Alternating vs. Steady Shearing (Torsion) Stresses, for SAE 4340 Steel, 172 ksi UTS	162
38	S-N Curves of Constant Probability of Survival of Stress at Constant Life, for SAE 4340 Steel, 140 km UTS. R. R. Moore Rotating Beam Tests	163
39	S-N Curves of Constant Probability of Survival of Stress at Constant Life, for SAE 4340 Steel, 190 ksi UTS. R. R. Moore Rotating Beam Tests	164
40	S-N Curves of Constant Probability of Survival of Stress at Constant Life, for SAE 4340 Steel, 260 ksi UTS. R. R. Moore Rotating Beam Tests	165
41	S-N Curves of Constant Probability of Survival of Stress at Constant Life, for SAE 4340 Steel, 230 ksi UTS. R. R. Moore Rotating Beam Tests	166
42	S-N Curves of Constant Probability of Survival of Stress at Constant Life. Heavy Solid Line, - Vacuum Melted SAE 4340 Steel 190 ksi UTS. Light Dash Line, - Aircraft Quality SAE 4340 Steel 190 ksi UTS	•
43	Tests of SAE 4340 Steel, UTS 140 ksi. Transverse Smooth Specimens. R. R. Moore Rotating Bending Tests	168
44	Tests of SAE 4340 Steel, UTS 190 ksi. Transverse Smooth Specimens. R. R. Moore Rotating Bending Tests	169
45	Tests of SAE 4340 Steel, UTS 230 ksi. Transverse Smooth Specimens. R. R. Moore Rotating Bending Tests	170
46	Tests of SAE 4340 Steel, UTS 260 ks1. Transverse Smooth Specimens. R. R. Moore Rotating Bending Tests	171
47	S-N Curves of Constant Probability of Survival of Stress at Constant Life. R. R. Moore Rotating Beam Tests of 4350 Steel, 300 ksi UTS	172
48	S-N Curves for 52100 Steel, Rc = 59	173
49	S-N Curves for 52100 Steel, R _c = 45	. 174
50	S-N Curves - 52100 Steel, Rotating Beam Specimens	175
51	S-N Curves for 8630 Cast Steel, Normalized and Tempered, 110.5 ksi UTS	176
52	S-N Curves for 8630 Cast Steel, Quenched and Tempered, 137.5 km1 UTS	. 176

PIGURE		PAGE
53	S-N Curves for 8640 Wrought Steel, Quenched and Tempered, 138 ksi UTS	- 177
54	S-N Curves for 8640 Wrought Steel, Normalized and Tempered, 108.5 kmi UTS	• 177
55	S-N Curve for 14B50 Steel, Smooth	• 178
56	S-N Curves for 98B40 Steel, 302.6 ksi UTS	• 179
57	S-N Curves for 98B40 Steel, 284 ks1 UTS	• 179
58	S-N Curves for 98B40 Steel, 270 km1 UTS	• 179
59	S-N Curves for 98B40 Steel, 245 ksi UTS	• 180
60	S-N Curves for 98B40 Steel, 204 km1 UTS	• 18o
61	S-N Curves for Tricent Steel, Smooth and Notched	• 181
62	S-N Curves for Crucible UHS-260 Steel, Smooth and Notched	• 182
63	S-N Curves for Super TM-2 Steel, Smooth and Notched	• 182
64	S-N Curves for Hy-Tuf Steel, 243 kmi UTS	• 183
65	S-N Curves for Super Hy-Tuf Steel, 260 kmi UTS	• 183
66	Approximate S-N Curves for Ferrovac WB-49 Steel, Not Nitrided and Nitrided	. 184
67	S-N Curves for Udimet 500, Hastelloy R-235, and GMR-235 Heat Resistant Alloys	• 185
68	S-N Curves for SAE H-11 Alloy Steel Bar Heat Treated to 280-300 km1 UTS	• 186
69 .	S-N Curve for H 23 Hot Work Tool Steel	• 187
70	S-N Curves for Heat Resistant Alloys Tested at Room Temperature .	• 188
71	S-N Curves for Inconel X Sheet, Heat Treated to 155 ksi Minimum UTS	• 189
72	S-N Curves for Inconel X-550 Alloy	• 190
73	1700°F S-N Curves for Inconel 713C at Zero Steady Stress and at Zero Alternating Stress	• 191
74	1700°F S-N Curves for Inconel 713C at Several Combinations of Steady and Alternating Stress	• 192
7 5	S-N Curves for S-816, Lapelloy, and Type 403 Alloys	• 193
76	S-N Curves for M-10 Steel, Rc 61-62, Not Nitrided and Nitrided. Constant Probability of Survival of Stress at Constant Life	. 10h

PIGURE	PAGE
77	S-N Curves for PH 15-7 Mo Stainless Steel, Condition RH950, Heat Treated to 225 ksi Minimum UTS
78	S-N Curves for 17-7 PH Stainless Steel, Condition TH1050, Heat Treated to 180 ksi Minimum UTS
79	S-N Curves for Refractaloy 26 at Room Temperature 197
80	S-N Curves for X-816 Alloy
81	S-N Curves for Sandvik Steel, for Two Heat Treatments 199
82	S-N Curves for 347 Stainless Steel, Showing Steady Plus Alternating Stress
83	S-N Curves for 403 Stainless Steel, Showing Steady Plus Alternating Stress
84	S-N Curves for Stellite 31 (X-40) Alloy
85	S-N Curves for 6.3% Mo-Waspalloy
86	S-N Curves for 16-25-6 Timken Alloy
87	S-N curves for Smooth Rene 41 Alloy, for Two Heat Treatments, at Room Temperature, 1200°, 1400°, and 1600°, With Zero Steady Loads (A = ->)
88	S-N Curves for Smooth Rene 41 Alloy, for Two Heat Treatments, at Room Temperature, 1200°, 1400°, and 1600°, With Steady Loads (A = 0.67)
89	S-N Curves for Smooth Rene 41 Alloy, for One Heat Treatment, at 1400° and 1600°F, With Steady Loads (A = 0.25)
90	S-N Curves for Aluminum Alloy 2014 (14S-T), Extruded 207
91	S-N Curves for Aluminum Alloy 2014-T6 (14S-T6) Rolled 208
92	Alternating vs. Mean Stress, for N = 107 Cycles, for 14S-T6 Aluminum Alloy, Rolled
93	S-N Curves for 2014-T6 Aluminum Alloy, Hand Forged. Longitudinal, and Short Transverse, Axial Tests 209
94	S-N Curves for Notched Alclad 24S-T3, Kt = 2.5
95	Alternating vs. Steady Stress for Notched Alclad 24S-T3, Kt = 2.5
96	S-N Curves for Alclad and for Bare 24S-T3, Smooth
97	S-N Curves for Aluminum Alloy 24S-T, Extruded
98	S-N Curves for 245-T4 Aluminum Allow Polled

PIGURE		PAGE
99	Alternating vs. Mean Stress, for N = 107 Cycles, for 24S-T4 Aluminum Alloy, Rolled	. 212
100	S-N Curves for 24S-T3 Plate, Fully Reversed	. 213
101	Alternating vs. Mean Stress for 24S-T3 Aluminum Alloy Plate	. 214
102	S-N Curves for 24S-T4 Aluminum Alloy, Hot Rolled	. 215
103	Alternating vs. Steady Stress, for Aluminum Alloy 24S-T, Smooth .	. 216
104	Alternating vs. Steady Stress, for Aluminum Alloy 24S-T, Notched, Kt = 2.05	. 216
105	S-N Curve for 24S-T3, Axial Loads, Fully Reversed at Three Speeds, on Notched Specimens, Kt = 4.0	. 217
106	Typical Load-Time Curves for Part of S-N Curve on Fig. 105	. 217
107	S-N Curves for 61S-T6 Aluminum Alloy. Fully Reversed Stress (A = ->)	. 218
108	S-N Curves for 61S-T6 Aluminum Alloy, for Steady plus Alternating Stress (A = 1.0)	. 218
109	S-N Curves for 61S-T6 Aluminum Alloy Sheet, for Steady Plus Alternating Stress (A = 1.0)	. 218
110	S-N Curves for Alclad 758-T6, Notched, Kt = 2.5	• 219
111	Alternating vs. Steady Stress for Alclad 75S-T6, Notched, Kt = 2.5	. 219
112	S-N Curves for Aluminum Alloy 758-T, Extruded, Smooth Specimens .	. 220
113	S-N Curves for Aluminum Alloy 75S-T6, Rolled Plate, Smooth Specimens	. 221
114	S-N Curves for Aluminum Alloy 758-T6, Plate. Fully Reversed Axial Stress	. 222
115	Alternating vs. Mean Stress, for Aluminum Alloy 758-T6. Fully Reversed Axial Stress	• 223
116	S-N Curves for 75S-T6 Aluminum Alloy, Hot Rolled	- 224
117	S-N Curve, 758-T6 Rolled and Drawn Rod, Smooth and Notched	• 2 25
118	S-N Curve, Extruded Bar 758-T6, Smooth	• 2 2 5
119	S-N Curve for 75S-T Aluminum Alloy, Showing Mean, and Scatter Band	.22 6
120	Log-Probability Diagram Showing Fatigue Life-Times, at Different Stresses, for 75S-T6 Aluminum Alloy	•226

FIGURE		PAGE
121	S-N Curves for 758-T6 Aluminum Alloy, for Various Probabilities of Failure	. 227
122	S-N Curve for 75S-T6 Aluminum Alloy, for Axial Loads, Fully Reversed, on Notched Specimens. Kt = 4.0	• 227
123	S-N Curves for 7075-T6 Aluminum Alloy, Hand Forged. Longitudinal, and Short Transverse, Axial Tests	• 558
124	S-N Curves for 76S-T61 Aluminum Alloy-Alternating Bending Stress Superimposed on the Indicated Steady Bending Stress	• 229
125	S-N Curves for 76S-T6l Aluminum Alloy-Alternating Torsion Stress Superimposed on Steady Torsion Stress	• 229
126	S-N Curves for Aluminum Alloy X76S-T. Rotating Bending Tests	• 230
127	S-N Curves for Vibratory Reversed Bending of X76S-T Aluminum Alloy	• 230
128	Alternating Stress vs. Steady Stress, for Notched X76S-T Aluminum Alloy. Kt = 3.6	. 231
129	S-N Curves for Aluminum Alloy 7076-T61. 10, 50, and 90% Probability of Survival of Stress at Constant Life	. 231
130	S-N Curves for 7079-T6 Aluminum Alloy, Hand Forged. Longitudinal, and Short Transverse, Axial Tests	. 232
131	S-N Curves for Magnesium Alloy AZ31X, Not Coated, and Coated Anodically to 0.0025 inch Thickness	. 233
132	S-N-R Curves for Magnesium Alloy FS-lh, Smooth	. 234
133	Steady Stress vs. Alternating Stress for Magnesium Alloy FS-lh, Smooth Sheet, for N = 107 Cycles	. 234
134	S-N Curves for Extruded Magnesium Alloy ZK60A-T5	. 2 35
135	Alternating Stress vs. Steady Stress for Extruded Magnesium Alloy ZK60A-T5, for N \approx 107 and 105 Cycles	. 236
136	Alternating Stress vs. Steady Stress for Extruded Magnesium Alloy ZK60A-T5, for N \approx 10 ⁴ and 5(10 ³) Cycles	• 237
137	S-N Curves for Magnesium Alloy J-1	- 238
138	S-N Plot of Fatigue Tests of FS-la (AZ31A-O) Magnesium Alloy	• 239
139	S-N Plot of Fatigue Tests of J-1 (AZ61A-F) Magnesium Alloy	- 240
140	S-N Plot of Fatigue Tests of O-1 (AZ8OA-F) Magnesium Alloy	• 241
141	S-N Curves for AZ-81T4 Cast Magnesium Alloy	. 242

FIGURE		PAGE
142	S-N Curves for Smooth Specimens of Magnesium Alloy HM-31 and HK-31 at Room Temperature and at 500°, 600° and 650°F, With Steady Loads (A = 1.0)	• 243
143	S-N Curves for Smooth Specimens of Magnesium Alloy HM-21 at Room Temperature and at 500° and 650°F, With Steady Loads (A = 1.0) and Without Steady Loads (A =	• 244
144	S-N Curves for Smooth and Notched Specimens of Titanium Alloy, RC 55 Type	• 24 5
145	S-N Plot of Fatigue Tests of Titanium Alloys Ti-150A and RC-130B	• 246
146	S-N Curves for Titanium Alloy RC-130B	247
147	S-N Diagrams for Ti-75A Titanium Alloy Tested at Different Speeds With and Without Coolant	• 248
148	Effect of Alloy Content on the Fatigue Properties of Ti-Cr-Mo Alloys	• 2 49
149	S-N Curves for 6 Al-4 Va Titanium Alloys, for Two Heat Treatments	• 2 49
150	S-N Curves for 6 Al-4 Va Titanium Alloy - Constant Probability of Survival of Stress at Constant Life	• 2 49
151	S-N Curves for 6 Al-4 V Titanium Alloy Bar, Heat Treated to 160 ksi Minimum UTS	• 250
152	S-N Curves for Aged, and Annealed, Smooth 7 Al-3 Mo Titanium Alloy, at 75°, 400°, 600°, 800°, and 1000°F, With Zero Steady Load (A = \ifftarrow)	• 251
153	S-N Curves for Aged, and Annealed, Smooth 7 Al-3 Mo Titanium Alloy, at 75°, 400°, 800°, and 1000°F, With Steady Loads (A = 0.67 and 1.0)	• 252
154	S-N Curve for Both Smooth and Notched Gray Iron	• 2 53
155	S-N Curves of Constant Probability of Survival of Stress at Constant Life. R. R. Moore Tests of Al-Ni Bronze	• 254
156	S-N Curves of Constant Probability of Survival of Stress at Constant Life. R. R. Moore Tests of Beryllium Copper	• 254
157	S-N Curves for Glass-Fiber-Reinforced Plastic Laminates	2 55
158	S-N Curves for Glass-Fiber-Reinforced Plastic Laminates	25 6
159	S-N Curves for a Heat Resistant Glass-Fiber-Reinforced Plastic Laminate, With and Without Superimposed Mean Stress	• 2 57
160	S-N Curve of a Heat Resistant Glass-Fabric Reinforced Plastic Laminate, at 45° With the Warp	• 2 58

FIGURE	PA	GE
161	S-N Curves for a Heat Resistant Glass Fabric Reinforced Plastic Laminate	58
162	S-N Curves of Heat Resistant Glass-Fabric Reinforced Plastic Laminates	59
163	S-N Curves for a Glass Fabric Laminate Plastic	6 0
164	S-N Curves for Natural and Laminated Wood	61
165	Approximate S-N Scatter Band for 200 Specimens of Natural and Laminated Woods	62
166	S-N Curve for Brush QMV Beryllium. Smooth Specimens. Rotating Bending Tests	63
167	Stress-Rupture Curves for QMV Beryllium at 1100°F 2	64
168	Approximate S-N Curves for Beryllium, Smooth and Notched. Steady Plus Alternating Stress, at Room Temperature 2	65
169	Approximate S-N Curves for Beryllium, Smooth and Notched. Alternating Stresses Only, at 1100°F	66
170	Approximate S-N Curves for Beryllium, Smooth and Notched. Steady Plus Alternating Stress, at 1100°F	67

SECTION I. INTRODUCTION

1.1 Purpose of This Report

The purpose of this report is to provide research and design engineers and metallurgists with, as nearly as possible, complete data as to the "room temperature" fatigue properties of structural materials, and a few high temperature properties, as determined in the laboratory. Also, since these properties can be so radically changed by so many different variables, as discussed in ref. (1)2, the report presents for each item all of the special conditions under which its reported fatigue properties hold good—as far as they are stated in the references.

The values of fatigue strength for a specified cycle life, listed under S_e in the tables, must of course be understood to be an average or median value. In other words, only about one-half of the specimens tested had as much strength, and the other half showed less than the tabulated strength. In the few cases in which a value of the "standard deviation" is given, some extrapolation downward may be justifiable, but it must be done cautiously. Reference (2) should be consulted for a discussion of the statistical analysis of fatigue data.

1.2 The Format of The Report

The information gathered from the references is presented in tables, figures and brief discussions. Each individual value of Se is given a line in the proper table, and an "Item" number in the table. In these tables, the data for each item begin on the left hand page, and are continued on the right hand page, on which the item numbers are repeated. Information not covered by the topics in the tables is given in the brief discussions to be found in Sections II to VII and on the figures referred to in the discussions. A list of the materials, with Table, Paragraph, and Figure numbers, is given at the back of the report.

1.3 Notation

A	Ratio of Alternating to Steady Stress
AC	Air Cool
	Cycles per minute
Elong.	Elongation (Static)
	Furnace Cool
Ht.	Heat
ksi	Thousands of psi
Kt	Geometric (Theoretical) Stress Concentration Factor
OQ	011 Quench
OQ R'	Ratio of Minimum to Maximum Stress
R	Root Radius of Notch
R.A.	Reduction of Area (Static)
RAT	Reduction of Area, Transverse
R.T.	
Se	Fatigue Strength, Fully Reversed Stress, for Indicated Number of Life Cycles
Sm	Mean (Steady) Stress
St. Dev.	Standard Deviation of Fatigue Strength
UTS	Ultimate Tensile Strength (Static)
WC	Water Cool
Ϋ́P	Yield Point (Static)
	•

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^{2/} Numbers in parentheses refer to the Bibliography.

SECTION II. STEELS

2.1 General

Steels given SAE or AISI numbers are placed in Tables I to III. Other steels, in general, are listed as Special Steels and will be found in Table IV. These are steels designed by the steel-makers, usually for various specific fields of application. Stainless steels, however, have been classified as Heat Resistant Alloys and listed in Table V, since they offer considerable resistance to corrosion under high temperature conditions.

The long-life $(N = 10^7)$ fatigue strength of smooth steel specimens, and also of specimens notched with theoretical stress concentration factors anywhere from 2.0 to 4.0, have been plotted on Fig. 1. Steels that have been carburized or nitrided are not plotted on the figure.

2.2 Discussion of Data in Tables I to IV

2.2.1 SAE Steels 1008 to 4335

Items 1-3 Ref. 3

These tests on SAE 1008 steel were run primarily to see if lower the carbon content nearly to the vanishing point would lower, or eliminate "fatigue limit" of the iron. Fig. 2 shows the S-N curves for the 1008 steefore and after decarburizing. It must be pointed out that the effect shown on this very low carbon steel cannot be extrapolated to predict the results of partial decarburization of modern high strength steels.

Items 4-5 Ref. 4

The 1020 steel was "hot-rolled bar stock . . . of electric melted steel". S-N curves are given on Fig. 3.

Items 6-23 Ref. 5

In this series of tests the "cast steels were supplied in coupon form, the wrought steels in the form of hot-rolled stock". Eight to eleven specimens were tested for each S-N curve. The tests were primarily to study the relative merits of cast and wrought steels. For the materials tested the authors conclude that "there is no advantage of one material over the other at either small or large numbers of cycles when critically shaped notches are present in steels tested in fatigue". Figs. 4 to 7 give S-N curves for the 1040 steel. (See also data on 4135, 4140, 8630 and 8640 steels).

Items 24-30 Ref. 6

Material is Smooth 2315 Steel. Specimens were carburized to a depth of 0.041" to 0.044". Fig. 8 shows S-N curves. These studies were made in connection with studies of the fatigue of full-scale rear-axle automobile gears. The gears failed at fatigue strengths, or lives, much less than the tests predicted, therefore the authors of reference 6 concluded that stress concentrations due to designs or machining marks, etc., were more responsible for the failures than the choice of one steel rather than another of those studied. NOTE: There is no particular significance in the fact that "Item 30" is in the same block as Item 27, on Fig. 8.

Items 31-33 Ref. 6

Material is Notched 2315 Steel. A peculiar design for notched R. R. Moore specimens was used. The design is shown in Fig. 9. Authors of ref. 6

say: "Stresses . . . were calculated at the surface opposite the notch. Because of the shape of the cross-section through the notch, this point is more highly stressed than in the center of the notch. Failure starts, however, at the intersection of the bottom of the notch with the surface where the stress is apparently highest. No method is known for calculating stress at that point; therefore, the value obtained for the surface opposite the notch was used in plotting curves". In the "Discussion", R. E. Peterson says: "An Approximation can be obtained by means of the Neuber solution, reference 7, which gives a stress concentration factor of 3.14 for the two-dimensional case and 3.47 for the three-dimensional case". S-N curves are given in Fig. 10.

<u>Items 34-37</u> Ref. 6

Material is Smooth 2330 Steel for Items 34-36 and Notched 2330 Steel for Item 37. See Items 24 to 33 above for general discussion. S-N curves for Smooth Carburized 2330 are shown in Fig. 11. S-N curve for Notched Carburized 2330 is shown in Fig. 12.

<u>Items</u> 38-39 <u>Ref. 8</u>

The "endurance limits" for this SAE 2340 steel were obtained from a few specimens. The reference shows an S-N curve, Fig. 13, for notched specimens only, based on eight specimens.

Items 40-44 Ref. 10

For this SAE 4130 steel, approximate S-N curves for fully reversed stressing, plotted from data in the reference, are given in Fig. 14. Fig. 15 shows the effect of mean (steady) stresses superimposed on the alternating stresses. In general, the S-N curves upon which these items depend were each based on from five to ten or fifteen specimens.

Items 45-52 Ref. 5

Discussion of Items 6-23 applies also to these items on 4135 and 4140 steel.

<u>Item 53</u> <u>Ref. 11</u>

Etching showed the grain flow of this 4320 steel to be transverse to the axis of the specimens. Static properties are given as determined at Wright Field "Tested transverse to the direction of rolling". Fig. 16 shows the S-N curve as traced from the reference report.

<u>Items 54-59</u> Ref. 12

Thest tests show the nitrided notch strength to be about triple the unnitrided notch strength for this 4320 steel. Comparison of Items 56 and 55, or 59 and 58, indicates that increasing the time of nitriding from 8 to 15 hours increased the long life fatigue strength of the specimens tested by about 15 percent.

Items 60-67 Ref. 13

Most of the data for static properties of this 4330 steel and all data for fatigue properties were scaled from various charts in the reference report. The material is described as "hot rolled from commercial, electric-furnace heats". The S-N curves taken from the report are given on Figs. 17-21.

Items 68-73

Ref. 14

These six values of Se for 4330 steel indicate variations among three different heats of steel, and between longitudinal and transverse specimens of each heat. The reference gives 95% confidence limits for each $S_{e,s}$ amounting to from 1.6 to 4.4 ksi. These tests were made by the Prot method which theoretically gives Se for infinite life. Static properties are averaged from tests of two to four specimens. The small differences among them are probably not as significant as they appear to be.

Items 74-77

Ref. 5

Discussion of Items 6-23 applies also to these items on 4335 steel.

2.2.2 SAE Steels 4340 and 4350

Items 1, 2

Refs. 15,16

It should be noted that by changing the heat treatment the item 2 steel was given a different microstructure and a reduced tensile strength. may be presumed that this accounts for the reduced fatigue strength of the item 2 steel. The method of computing stresses as reported in reference 15 was reviewed in reference 16 and certain inaccuracies pointed out. The stresses reported herein are based on the findings of reference 16, both in the data tables and on the S-N curves, Figs. 22 and 23.

The S-N curves, Figs. 22 and 23, show the statistical variability of the two steels. Note that the finite life variability was obtained by analyzing constant-stress data, whereas the endurance limit variability was obtained by analyzing constant-life data. A large number of specimens was used for these studies, which gives a high degree of confidence to the results, for the type of specimen used and the manner of testing. The "endurance limits" for these items may be presumed to be lower than would have been obtained if the specimens had been "round, rotating" instead of "rectangular-cantilever". (See Figs. 14, 15, 16 of reference 23). The implication of the report, reference 15, is that inclusions rather than surface finish, determined fatigue strength. (Surface finish is not reported for these specimens.).

Items 3-12

Ref. 17

The reference reports a size-effect study on specimens of SAE 4340 steel for sizes from 1/8 inch to 1 3/4 inch diameter. There is an implied conclusion in the reference that size effect is extremely small, in case of extrapolating from test results on specimens in the neighborhood of 2" diam. to specimens of greater size.

Considerable variability appears in the detailed data of this reference. The authors of the reference believe it to be due, at least to a considerable degree, to non-uniformity both transversely and longitudinally in metallurgical structure of the 3" diameter bars used as source material. (Photomicrographs show pronounced bending in some of the longitudinal sections.) This is thought, by the authors, to account for the disproportionally low endurance limit of the notched 1 3/4" diameter specimens.

Fig. 24 shows S-N curves from the reference report. Each of the curves, as shown, is based on only about a dozen test specimens.

<u>Items 13-16</u> <u>Refs. 18,19,20</u>

Fig. 25 based on reference 20, shows individual S-N curves for fully reversed axial tests on four hardnesses of the steel. The curves for smooth specimens were derived by extrapolation from tests on notched specimens. The two curves for the 190 ksi UTS steel represent specimens from different bars.

WADD TR 60-42

Twelve specimens were tested for each S-N curve on Fig. 25.

Items 17-20

Ref. 21

These steels are called SAE 4340 but they are somewhat low in carbon, particularly items 19 and 20. This fact should be taken into account in considering either the static or the fatigue strengths, both of which might have been a little higher if the carbon had been chosen to the usual 4340 specifications.

It is to be noted that two heats of steel were used, each hardened to about the same static strength as the other. However, one of the heats (items 17 and 18) showed low ductility in the direction transverse to forging, and correspondingly low fatigue strength in the transverse direction. This heat also showed more variability in the transverse tests than in the longitudinal tests.

Each value of Se in the data table is based on a staircase test of about 50 specimens. The S-N curves, Figs. 26 and 27, were obtained by combining the staircase (2) test results with the results, in each case, of about 15 additional specimens tested at constant stress. The 2 or curves show scatter in finite life. Scatter in long-life strength, shown in the data table, was determined from the staircase tests.

Items 21-26

Ref. 22

In this report on high temperature fatigue tests, a considerable amount of data were obtained on 4340 steel at room temperature. These data are presented herein. The discovery of a few unusually large inclusions led to considerable study of the cleanliness of SAE 4340 steel. "Micro-examination of the specimens made by the metallurgical laboratory of the Republic Steel Corporation revealed some fine dispersed globular non-metallic inclusions throughout the matrix of the steel. . . . the inclusions proved to be carborundum crystals with silicate glass, . . . which is probably a deoxidation product rather than a product of refractory erosion. . . . Check tests with supposedly clean material, submitted by Republic Steel Corporation especially for this purpose, revealed negligible influence in this respect. However, in a few specimens of this material, submitted by Republic Steel Corporation, small inclusions of the same appearance were found, which may indicate that the SAE 4340 steel in general is permeated by this composition".

S-N curves, Figs. 28 and 29, give information regarding items 21, 23, 24 and 26. Data for items 22 and 25 were obtained from tests run at "zero to maximum tension". In such tests, the mean (steady) stress varies continuously throughout the S-N curve, so that a curve of the type of those on Fig. 29 cannot be drawn. Alternating stress-steady stress diagrams (modified Goodman diagrams) are given for both smooth and notched specimens on Fig. 30.

Items 27, 28

Ref. 23

Fig. 31 shows the "control" S-N curves for 4340 steel obtained by the authors of reference 23 incidental to the main purpose of their tests, which were studies of the effect of varying amplitude.

Items 29-39

Ref. 24

Fig. 32 shows results of tests of 4340 steel, especially at high stress levels. Heating effects shortened life of high stress level specimens so seriously that cpm were reduced, for them, from 3450 to 90.

Note that curves for items 38 and 39 show alternating stresses only, and that for any value shown on these curves there was also a steady stress of

magnitude equal to the maximum tensile alternating component; - in other words, the tests were "pulsating", i.e., zero to tension.

Fig. 33 shows mean "endurance limits" increasing linearly with UTS, up to 220 ksi UTS. For higher tensile strengths the "endurance limits" have, in general, been found to increase at a slower rate for this steel.

Item 40

Ref. 25

The 4340 steel was taken from two propeller shanks. Reference states that statistical studies show no significant difference in the strength of the two shanks, therefore, the data from the two shanks were combined.

From Tables II and III, p. 887 of the reference, data were taken, and analyzed by the Step Method (reference 2), which gave the mean endurance limit at 10 cycles as 86 ksi, and the standard deviation from the mean as 8.0 ksi, for this steel which had been heat-treated to about 160 ksi UTS.

Items 41-56

Ref. 26

The S-N curves for 4340 steel shown on Figs. 34, 35, were "drawn separately by inspection in order to represent the trend of the data".

The effect of steady stress, as shown in the reference, is shown on Figs. 36, 37. Of course, stresses plotted to the right of the yield-point boundary are more of the nature of modulus-of-rupture points, since the nominal formula used for calculating them (Mc/I) does not apply in the plastic region. Note that torsional steady stress, according to Fig. 37, appears to have only a slight effect on torsional alternating stress.

Items 57-62

Refs. 27,28

S-N curves for 4340 steel are shown on Figs. 38,39,40. At least 280 specimens were used in determining each of the six S-N curves on these figures. Between 170 and 200 additional specimens were tested and the results used in determining the values of Se for each of the items 57, 59, and 61. This gives an unusual degree of reliability to these values of Se, but only for the single heat from which all of the specimens were taken.

Items 63-67

Ref. 29

The S-N curves for 4340 steel, for items 63 and 64, appear on Fig. 41. Two hundred or more specimens were used for each of the S-N curves. The tests were made to "investigate the actual fatigue behavior of SAE 4340 steel in what has been reported to be a brittle range". The reference states that "the reported brittleness of the 230 ksi UTS steel tested is perhaps not so serious as had been thought".

For items 65 and 66, the S-N curves are given on Fig. 42. About 450 specimens of vacuum melted steel were tested for each of the curves. Attention is called, in the reference, to the fact that "the notches cut in the 'notched' vacuum melted specimens reduced the life and strength of the steel to practically the same values previously found for the air-melted steel".

The steel used for item 67 was made by the consumable electrode method. Only 20 specimens were tested and the reference suggests that the value of $S_{\rm e}$ as determined by an abbreviation of the Prot method is subject to some uncertainty.

Items 68-71

Ref. 30

These tests of the transverse fatigue properties of SAE 4340 steel were made on steel from the same heat that was used for items 57-72. The purpose

was to investigate the relative effect of non-malleable spheroidal inclusions on transverse as compared with longitudinal specimens. The reference concludes that "the non-malleable inclusions in the present steels are not important causes of anisotropy". S-N ourves for the four different hardnesses are given in Figs. 43 to 46.

<u>Items 72-75</u> <u>Ref. 5</u>

These items show the effect of different heat treatments on smooth and notched 4340 steel.

<u>Items</u> 76-85 Ref. 14

These ten values of Se for 4340 steel indicate variations among five different heats of steel, and between longitudinal and transverse specimens of each heat. The reference gives 95% confidence limits for each Se, amounting to from 2.0 to 3.8 ksi. These tests were made by the Prot method, which theoretically gives Se for infinite life. Static properties are averaged from tests of two to four specimens. The small differences among them are probably not as significant as they appear.

Items 86-87 Ref. 29

The S-N curves for this 4350 steel, shown on Fig. 47, are based on about 250 smooth and 250 notched specimens.

Items 88-95 Ref. 14

These eight values of S_e for 4350 steel indicate variations among four different heats of steel, and between longitudinal and transverse specimens of each heat. The reference gives 95% confidence limits for each S_e , amounting to from 3.5 to 4.5 ksi. These tests were made by the Prot method which theoretically gives S_e for infinite life. Static properties are averaged from tests of two to four specimens. The small differences among them are probably not as significant as they appear to be.

2.2.3 SAE Steels 52100 to 98B40

Items 1-22 Ref. 32

Each S-N curve of the 22 that are shown on Figs. 48 and 49 was drawn to represent either 7 or 8 specimens. There is not enough information to warrant any assumption as to the variances of the "fatigue strengths" listed in Table III. (The fatigue strengths are given as listed in the reference report.) Tentative conclusions, as to the effect of various degrees of gentleness in surface finishing, as shown in the table below, are drawn in the report, but it is shown that the differences are so small in many cases that they may not be significant. Much greater differences occur, in general, between the tests of round and of flat specimens of the same material. In addition to the effect of shape, there may be some small difference chargeable to the difference in the speeds of testing round and flat specimens.

Surface Treatment of Specimens Tested for Figs. 48, 49

Item	Surface	Treatment	Туре	No. of Specimens
1 2 3	Gentle grind Gentle grind Gentle grind	-	Round	8 7
56	Dry grind Gentle grind	& hand polish & heat treat. & hand polish	 11 11	8 7 7

Surface Treatment of Specimens Tested for Figs. 48, 49 (Continued)

Item	Surface	Treatment	Туре	No. of Specimens	
7	Gentle grind		Flat	8	
8	Gentle grind	& hand polish	Ħ	8	
Q	Severe grind		#	Ř	
7 8 9 10		& hand polish	91	8 8 8 8	
11	Gentle grind	& hand polish	Round	7	
12	Gentle grind	& tumble	Ħ	7	
13	Gentle grind		**	Ż	
14	Gentle grind		Ħ	Ŕ	
15		& hand polish & heat treat.	W	8 6	
13 14 15 16	Gentle grind		11	7	
17 18	Severe grind	& shot peen	Flat	8	
18	Gentle grind	& shot peen	N	8	
19	Severe grind	& tumble	11	8	
20	Gentle grind		Ħ	8	
21		& electropolish	n	. Ř	
25	Severe grind		Ħ	8 8 8 8 8	

Items 23-26

Ref. 32

The four sets of specimens were cut from a tube of $3.5/8^{\rm H}$ O.D. and $5/8^{\rm H}$ I.D., so that Items 23 and 25 were from the bore of the tube and Items 24 and 26 were from the outside of the tube.

Items 27-32

Ref. 33

A comprehensive study by Styri on 52100 steel. Particular attention is given to the apparent lack of an endurance limit for this steel in the high hardness state, Re 60, - and to the very considerable scatter in the test results. Fig. 50 shows tests apparently comparable with R. R. Moore rotating cantilever tests. Size of specimens is not stated. A supplementary set of tests was run on a special (vacuum) melt of 52100 to see if the size of inclusions affected the degree of scatter. "A wide scatter appears here also, in spite of the great reduction in size of foreign inclusions".

Items 33-40

Ref. 5

The discussion of Items 6-23 in paragraph 2.2.1 applies also to these items on 8630 and 8640 steel. S-N curves for cast 8630 steel are given in Figs. 51 and 52, and for wrought 8640 steel in Figs. 53 and 54.

Items 41-42

Ref. 8

In the case of the boron steel 14B50, the reference shows an S-N curve, Fig. 55, for smooth specimens only.

Items 43-52

Ref. 13

For the data in Table III on this boron steel, 98B40, values were scaled from graphs in the reference report. Figs. 56-60 show the S-N curves as given in the report.

2.2.4 Special Steels

Items 1-6

Ref. 34

S-N curves for these tests of Tricent Steel (now called 300-M) are given on Fig. 61. Also on the figure are the curves for notched specimens of Kt = 3, 5, and 8. The S-N curves appear in the reference up to 10^5 cycles only, but as they are drawn it is reasonable to assume they would not show much decrease in values of S_e if they had been carried out to 10^7 cycles.

Items 7-9

Ref. 29

The two items 7 and 8 on Tricent-Steel apply to steel of about the same tensile strength as that of item 1. There is about 15 percent difference between values of Se for these items and that of item 1. Attention should be given to the many differences between the conditions of heat treatment, testing procedures, etc., in attempting to account for the differences in fatigue strength.

Item 9, Super Hy-Tuf, was tempered at the same temperature as was Item 5, but was partially stress relieved (300°F). However, it has about the same fatigue strength as item 5.

Items 10-13

Ref. 34

S-N curves for these steels are given on Figs. 62 and 63 for both smooth and notched specimens.

Items 14-17

Ref. 13

Data for the Hy-Tuf and Super Hy-Tuf steels were scaled from charts in the reference. S-N curves are given in Figs. 64-65.

SECTION III. HEAT RESISTANT ALLOYS

3.1 General

Many of the fatigue strength values given in Table V for these heat resistant alloys are the room temperature strengths of materials that had been prepared for high temperature testing. The term "Heat Resistant" is not well defined, and the inclusion of such alloys as are listed in Table V is rather arbitrary. Items 64 to 74 of Table XII, 67 to 86 of Table XIII, and 51 to 63 of Table XIV might have been included in Table V.

3.2 Discussion of Data in Table V

Items 1-4

Ref. 35

The effect of nitriding this Ferrovac WB-49 steel is shown graphically on Fig. 66. Notched fatigue strength is considerably increased by the nitriding.

Items 5-6

Ref. 36

The fatigue data for this GMR-235 "high temperature" alloy given in Table V are room temperature fatigue properties of a material that had been prepared for testing at temperatures of 1200°F and 1650°F. Room temperature S-N curves are given on Fig. 67 together with two other alloys.

Item 7

Ref. 37

For Halmo tool steel the reference gives a small S-N curve indicating that the fatigue strength at 10° cycles is appreciably lower than at 10° cycles. The curve is based on about a dozen and a half specimens.

Items 8-9

Ref. 36

Comments on items 5-6, above, apply to this Hastelloy R-235 alloy. See Fig. 67 for S-N curve.

Items 10-11

Ref. 38

S-N curves for H-11 alloy bar steel are given on Fig. 68. Special attention should be given to the scale of stresses on this figure. They show the combination of steady and alternating stresses at the various stress levels. Note that as steady stresses increase, the alternating stresses also increase.

Item 12

Ref. 35

An S-N curve for this H-23 steel, based on 107 specimens, is given on Fig. 69.

Items 13-14

Refs. 39, 38

The data on Inconel X come from two references. Regarding item 13, the authors of reference 39 made "exploratory tests on several" heat resistant materials (S-816, Inconel X, Type 403, TP-2B, TP-2-R). For each of the room temperature S-N curves on Fig. 70, they used five or six specimens. They say:- "Although the scatter in the fatigue data is generally relatively small, these data must be considered only approximate since so few specimens were used for each curve".

The S-M curve for Incomel X, derived from reference 38, shows a combination of steady and alternating stresses on Fig. 71.

Items 15-16

Ref. 40

Values of $S_{\mathbf{e}}$ for the Inconel X-550 were scaled from the S-N curves on Fig. 72.

Items 17-26

Ref. 41

These items give high temperature $(1700^{\circ}F)$ data on cast Inconel 713C. The S-N curves, Figs. 73, 74, were derived from figures given in the reference. Whereas the reference figures show crest stresses (steady plus alternating), Figs. 73, 74 show the separate components of crest stress. Notice that there are two scales on Fig. 73, one for the lower pair of curves which show the effect on reversed stresses at $1700^{\circ}F$, the other scale for the upper pair of curves which show the effect (creep) of a steady stress only (A = 0).

Item 27

Ref. 42

S-N curves for Lapalloy, and two other alloys for comparison, are given on Fig. 75. Note that each curve is based on a small number of specimens.

Item 28

Ref. 37

For M-l steel the reference gives a small S-N curve indicating that the fatigue strength at 10° cycles is appreciably lower than at 10° cycles. The curve is based on about a dozen and a half specimens.

Item 29

Ref. 37

For MV-1 steel, the comment above in item 28 applies.

Items 30-33

Ref. 35

The M-10 steel, whose S-N curves are given in Fig. 76, shows considerably more improvement in notched fatigue strength after nitriding than is shown in the WB-49 steel (Items 1-4).

Items 34-35

Ref. 43

S-N curves, based on five or six specimens each, for the N-155 alloy are given on Fig. 70. The authors of the reference say: - "Since only a small number of points were obtained for each curve, the diagrams presented are only approximate".

Items 36-37

Ref. 38

The S-N curves, Fig. 77, for PH 15-7 Mo Stainless Steel show the combined steady and alternating stress separately on the scale of stresses. Note that the steady stresses increased as the alternating stresses increased.

Items 38-39

Ref. 38

Comments on items 36-37, above, apply to Fig. 78 for 17-7 PH steel.

Items 40-45

Ref. 44

Although it may appear that the change in grain size of this Refractalloy 26 is responsible for the sharp decrease in long-life strength

of the smooth specimens, the author of the reference points out that "the two grain sizes were obtained by using two different solution treatments" (see Table V). He goes on to say: - "Consequently, it is possible that there may be metallurgical dissimilarities other than grain size". S-N curves are given on Fig. 79.

Items 46-63 Refs. 39,42,40

The data on S-816 alloy come from three references. Item 46 is one of the materials mentioned in the discussion of Items 13-14, above. The S-N curves are shown on Fig. 70.

For item 47, an S-N curve is shown on Fig. 75, together with two other alloys for comparison. Note that each curve is based on a small number of specimens.

S-N curves for items 48-50 are given on Fig. 80. The values of S_e in Table V were scaled from Fig. 80.

The data for S_m and S_e for items 51-63 were derived from values scaled from S-N curves of "crest" stresses in the reference. Each curve was based on at least five specimens but in no case more than ten specimens.

<u>Items 64-67</u> Ref. 4

The Sandvik steel was supplied to the investigator by Sandvikens Jernwerks Aktiebolag, Sandviken, Sweden. S-N curves for smooth and notched specimens and for two heat treatments are given on Fig. 81. Varying the heat treatment affected the fatigue strength of smooth specimens appreciably, but not the notched ones.

Items 68-70 Ref. 45

The material is 347 stainless steel. The S-N curves on Fig. 82, derived from curves in the reference, show the steady and the alternating components of the stress, on the stress scale. Note that the steady stress increases as the alternating stress increases.

Items 71-77 Refs. 45,39,42,40

The data on 403 stainless steel were collected from four references. For items 71-73, S-N curves on Fig. 83 show the steady and the alternating components of the stress.

For item 74, an S-N curve is shown on Fig. 70. This is one of the materials referred to in the discussion of items 13-14, above.

Item 75, 403 stainless steel, appears on Fig. 75 as one of three alloys shown on the figure for comparison. Note that each curve is based on a small number of specimens. Attention is called to the different values of Se, at 2(107) cycles, in items 74 and 75. This primarily due to differences in heat treatment of this martensitic steel.

Items 76, 77 refer to fatigue strength at two different values of cycle life for 403 stainless steel heat treated much the same as the steel in item 75.

<u>Items 78-80</u> <u>Ref. 40</u>

The "scatter diagrams" of the tests of Stellite 31 showed "relatively large scatter" which the reference says is "not unusual for cast materials and is probably due to the large primary grain size". The S-N curve, Fig. 84, show

an inversion of strength, for long-life notched specimens, that could perhaps be accounted for by the large scatter in a relatively small number of specimens. Values of S_e in Table V were scaled from Fig. 84.

Items 81-83

Ref. 40

Values of S_e for this 16-25-6 Timken Alloy were scaled from the S-N curves on Fig. 86.

Items 84-85

Ref. 39

These heat resistant materials TP-2B and TP-2-R (molybdenum with and without tungsten) are among those referred to in the discussion of items 13-14. Their S-N curves appear on Fig. 70.

Items 86-87

Ref. 36

Comments on items 5-6, above, apply to this Udimet-500. The S-N curves appear on Fig. 67.

Items 88-90

Ref. 40

S-N curves for this 6.3% Mo-Waspalloy are given on Fig. 85. Values of Se in Table V were scaled from Fig. 85.

Items 91-102

Ref. 46

These are evaluation tests of General Electric's heat resistant nickel base alloy Rene 41, at room and at high temperatures. Two heats of this alloy were tested, but because of the small number of specimens available the variation between the heats could not be investigated completely. The values of Se given in Table V were scaled from the S-N curves given in Figs. 87, 88, 89. Curves on Fig. 87 show fully reversed tests. Those on Figs. 88, 89, show steady loads combined with alternating loads.

The speed of testing is not given in the reference, therefore total elapsed time for 107 cycles cannot be stated. The "creep" effect presumably would be considerable at the high temperatures used, and would depend upon elapsed time. This suggests caution in using the values of Se given.

SECTION IV. ALUMINUM ALLOYS

4.1 General

The titles of Tables VI to XI list the respective aluminum alloys according to the present Alcoa number code, but give also, in parentheses, the corresponding former code number. Within the tables, in the discussions, and on the figures, the code numbers used by the respective references appear.

4.2 Discussion of Data in Tables VI to XI

4.2.1 Aluminum Alloy 2014 (145)

Items 1-2

Ref. 47

"Extruded" material - smooth - surface polished but smoothness not measured although "believed" to be about 20 micro-in. Fig. 90 shows tests on same material, under similar conditions excepting shape, machine, and speed. ("Sharp edges in the gage section were broken with emery paper".) Note that only nine specimens were tested for each S-N curve.

Items 3-6

Ref. 48

S-N curves for smooth and notched specimens are given on Fig. 91. The effect of steady stress on the 107 cycle strength of this 2014-T6 material is shown on Fig. 92.

Items 7-10

Ref. 49

The S-N curves, Fig. 93, show small differences between longitudinal and short transverse fatigue properties for this hand forged 2014-T6 alloy. (The forgings were 3" x 6" x 38" in size.) Similar curves are shown on Figs. 123 and 130 for other aluminum alloys.

4.2.2 Aluminum Alloy 2024 (24S)

Items 1-4

Ref. 50

These items show the effect of certain surface treatments on the alloy.

The anodizing process was as follows:

- 1. Clean with hot caustic soda bath.
- 2. Immerse in 15% H2SQ4 both at 70°F.
- 3. Seal in water at 1850F.

For anodized and painted specimens, a fourth step:

4. Paint with zinc-chromate primer and normal finishing of Preparakote.

Microscopic examination of anodized surface showed that "entire surface was pitted".

The reference showed S-N curves from 10⁴ to 10⁷ cycles, for which 13 to 16 specimens were used for each curve.

The specimens used for items 3 and 4 were subjected to corrosion

during the fatigue stressing by "allowing plain tap water to drop slowly upon an extremely light-weight wick in contact with the specimen".

The author of reference 50 concludes that anodizing is detrimental. As a matter of fact, the anodized specimens (Item 2) appear to have about the same strength as specimens subjected to tap water corrosion (Item 3).

Item 5

Ref. 51

The curves, Figs. 94, 95 are for notched Alclad 24S-T3. They were traced from reference 51.

Items 6, 7

Ref. 52

Item 6 is Alclad and Item 7 is Bare 24S-T3. The type of testing machine used made it impossible to run a test at absolutely zero mean stress and constant amplitude. However, the variations were of about the same order as the scatter shown on the S-N curves, Fig. 96, which were traced from the reference report.

Items 8-9

Ref. 47

"Extruded" material - smooth - surface polished but smoothness not measured although "believed" to be about 20 micro-in. Fig. 97 shows tests on this material, under same conditions excepting shape, machine, and speed. ("Sharp edges in the gage section were broken with emery paper".) Only 6 or 8 specimens were tested for each S-N curve.

Items 10-13

Ref. 48

"Rolled" material - smooth and notched specimens of Alloy 245-T4. Fig. 98 shows S-N curves for zero mean stress. The reference report gives also S-N curves for various constant ratios of alternating to mean stress. In this type of graph the mean (steady) stress is changing continuously throughout the graph. Therefore, these curves are not reproduced herein, but the equivalent information for 107 cycle life is given in Fig. 99.

Items 14-18

Refs. 9,10,53,54

Material, 24S-T3, commercial sheet, 0.090" thick. Each S-N curve depends upon from 5 to 12 or 15 tests. Authors believe that errors in load values do not exceed ±5%.

Fig. 100 shows S-N curves for fully reversed loading. Fig. 101 shows the effect of mean (steady) stress in reducing the alternating stress.

Items 19-21

Ref. 55

Material is 24S-T4 hot-rolled aluminum alloy. The authors, by slow bend tests on specimens fatigued part-way toward failure, determined that 24S-T4 has superior energy - absorption capacity, compared with 75S-T6, and lower notch-sensitivity. However, by re-heat treating 24S to approximately the hardness of 75S-T6, it was made to behave closely like 75S-T6.

Fig. 102 shows S-N curves for smooth and for notched 24S-T4, for fully reversed stresses.

Items 22-23

Ref. 56

Axial tests are reported in the reference at various "stress-ratios", i.e., combinations of steady and vibratory components of stress. Figs. 103 and 104 were plotted from Table 8 of the reference.

WADD TR 60-42

Item 24

Ref. 57

The material tested was thin 24S-T3 aluminum alloy. Tests were run at three significantly different rates in cpm, as shown on Fig. 105. It is probable that the S-N curve would actually be three different curves, if a complete set of tests_had been made, at each of the three rates of cpm, for the range N = 1 to $N = 10^7$ cycles. No information is given as to the variability of the material. The reversal of stress from the tests at less than 50 cpm was not sinusoidal. Typical load-time curves, traced from the reference, are shown in Fig. 106.

4.2.3 Aluminum Alloy 6061 (618)

Items 1-4

Ref. 58

The S-N curves on Figs. 107 and 108 show the effect of "zero to tension" stressing on the fatigue strength of the alloy. The curve for item 3, based on only three specimens, must be taken as less precise than the other curves. The stress scale for Fig. 108 shows the steady component separately from the alternating component.

Items 5-7

Ref. 45

Curves for these "zero to tension" tests on sheet 618-Tó alloy. shown on Fig. 109, are based on larger numbers of specimens than those discussed above. However, they are not particularly different in the region 105 to 107 cycles.

4.2.4 Aluminum Alloy 7075 (758)

Ref. 51

The S-N curves shown on Figs. 110, 111, are for notched Alclad alloy 758-T6. They were traced from ref. 51.

Items 2-13 Ref. 47

These items come from a study of the effect of type of specimen on fatigue properties of 75S-T6 aluminum alloy. It must be pointed out that the test results depend upon not only the type of specimen but also the type of testing machine and the speed of testing.

Fig. 112 shows results of tests, items 2 and 3, on extruded "75S-T". The surfaces were polished but the smoothness was not measured, although it was "believed" to be about 20 micrc-inches. "Sharp edges in the gage section were broken with emery paper". From 7 to 11 specimens were used for each S-N curve. For 75S-To plate material, S-N curves are given on Fig. 113. From 10 to 20 specimens were used for each of these curves.

Items 14-18

Refs. 9,10,53,54

The material is 75S-T6, commercial sheet, 0.090" thick. Each S-N curve depends upon from 5 to 12 or 15 tests. The authors believe that errors in load values do not exceed ±5%.

Fig. 114 shows S-N curves for fully reversed loading. Fig. 115 shows the effect of mean (steady) stress in reducing the alternating stress. It should be noted that the curves on Fig. 115 are for the most part concave, which suggests that the straight-line "Goodman" diagram may not be conservative in all cases.

Items 19-21

Ref. 55

The material is 758-T6 hot-rolled aluminum alloy. The authors, by slow bend tests on specimens fatigued part-way toward failure, determined that 758-T6 has poorer energy-absorption capacity than 248-T4, and higher notch-sensitivity. However, by reheat-treating 758 to approximately the hardness of 248-T4, it was made to behave closely like 248-T4. Fig. 116 shows 8-N curves for smooth and for notched hot-rolled 758-T6, for fully reversed stresses.

Items 22-24 Ref. 59

Fig. 117 shows S-N curves for smooth, and for notched, 75S-T6 Rolled and Drawn Rod. The plotted test points showed no apparent difference between longitudinal and transverse specimens. The crosses show anodic coatings, of thickness as follows: X = 0.00009" thick; + = 0.0005" thick. Authors conclude that the thin coat may be beneficial to smooth specimens, - and that notched specimens are not particularly sensitive to either thin or thick coatings.

Fig. 118 shows S-N curves for 75S-T6 Extruded Bar. Here, as in Fig. 117, the thin coat of anodizing material appears to slightly improve the fatigue strength of the alloy.

Item 25 Ref. 23

Fig. 119 shows the "mean" S-N curve and the "scatter band" for a total of 30 specimens. Caution: A "scatter band" is not a "probability" curve". Its width depends upon the variability of the material and the number of specimens tested. Increasing the number of specimens usually increases the width of scatter bands. For the material used in these tests the heat treatment was not given, but the static properties are about the same as others given in the data table for 75S-T6 aluminum alloy.

Item 26 Ref. 60

The material is 75S-T6. Fig. 120 shows the results of testing large numbers of specimens, plotted on logarithmic normal-probability paper. The lines are by no means straight, but by using a best-fit straight line for each stress level, S-N curves were plotted as shown in Fig. 121.

<u>Item 27</u> <u>Ref. 57</u>

Material tested was 75S-T6 Aluminum Alloy. Tests were run at three significantly different rates in cpm, as shown on Fig. 122. It is probable that the S-N curve would actually be three different curves, if a complete set of tests had been made, at each rate of cpm, for the range N=1 to $N=10^7$ cycles. No information is given as to the variability of the material. The reversal of stress for the tests at less than 50 cpm was not sinusoidal. Typical load-time curves, traved from the reference, are shown in Fig. 106.

Items 28-31 Ref. 49

The S-N curves, Fig. 123, show considerable difference between longitudinal and short transverse smooth specimens of the hand forged alloy, but no significant difference for notched specimens. (The forgings were $3^n \times 38^n$ in size.) Similar curves are shown on Figs. 93 and 130 for other aluminum alloys.

4.2.5 Aluminum Alloy 7076 (768)

Items 1-9

Ref. 61

This material is 76S-T61, originally designated as M68, and referred to in reference 62 as X768-T.

Fig. 124 shows S-N curves for bending, without and with superimposed steady bending stresses.

Fig. 125, similarly, shows S-N curves for torsion, without and with superimposed steady torsion stresses. Reference 61 also gives various tables and curves showing combinations of alternating bending and torsion with superimposed steady bending and torsion.

Items 10-21

Ref. 62

These tests were run in 1941 or 1942, on material that at that time was designated X76S-T.

It will be noticed that the composition and heat treatment are reported as identical with those reported in reference 61, for 768-T61. There are not enough data regarding any one test to determine even approximately the variability of the material. Figs. 126 and 127 give S-N curves for this material, and Fig. 128 shows, for notched material, the relation of alternating to steady stress.

Items 22-23 Ref. 29

These tests were run to investigate the applicability of the Prot method of testing to aluminum alloys. The reference suggests the possibility that the much higher values of fatigue strength obtained by the Prot method may be due to some "coaxing" effect. Long-life S-N curves are given on Fig. 129.

4.2.6 Aluminum Alloy 7079

Items 1-4

Ref. 49

The S-N curves, Fig. 130, show some difference between longitudinal and short transverse smooth specimens of the hand forged alloy, but no significant difference for notched specimens. (The forgings were 3" x 6" x 38" in size.) Similar curves are shown on Figs. 93 and 123 for other aluminum alloys.

SECTION V. MAGNESIUM ALLOYS

5.1 General

Although there are numerous items in Table XII, a large number of them do not show the tensile (static) strength. Inspection of the Table will show that there seems to be little, if any, correlation of fatigue with static strength, so that the missing static strengths would be of only academic interest. A few data are given in Table XII (items 64 to 74) for high temperature fatigue.

5.2 Discussion of Data in Table XII

Items 1-12 Ref. 63

Regarding these tests on AZ31X, the reference says that the "HAE" process "produces electrolytically on magnesium alloys a nonmetallic coating that is hard and corrosion-resisting". The reference states that the coating reduced the fatigue strength by approximately 1000 psi for each 0.001 inch of coating. Several specimens were exposed to warm salt spray for five days then fatigue tested. The reference states that fatigue resistance was generally, but not invariably, not decreased by exposure to the spray. Fig. 131 gives S-N curves for item 1.

Items 13-29 Ref. 64

The material is Dow Chemical Co's. FS-1 alloy. Heat treatment is not specified in the reference, but the items marked FS-la are presumably annealed and those marked FS-lh are presumably hard rolled. Most of the data were from sheets, and to avoid buckling from compression the stress ranges for these tests were kept between zero and a maximum tension.

Warning: The reference says: "... it is recommended that the test bar data presented here not be used quantitatively for design values, but rather, simply for a qualitative comparison of materials".

Items 30-43 Ref. 64

The warning above applies also to the data on the magnesium casting alloys, C-AC, C-HT, C-HTA, and C-HTS.

Items 44-48 Ref. 65

Material is Dow FS-lh. Fatigue strengths were measured in terms of R (ratio min. to max. stress per cycle).

Fig. 132 shows the S-N-R curves, i.e., the curves for crest stresses. Fig. 133 was derived by converting values scaled from Fig. 132 into equivalent separate steady and vibratory components for 10° cycles.

Items 49-51 Ref. 66

Material is magnesium alloy ZK60A-T5 (Dow Chem.), Extruded bar stock. This is a "solid solution precipitation hardening type with Mg-Zn compound as the submicroscopic precipitate".

Fig. 134 shows S-N curves, for fully reversed stress, of smooth and of notched specimens.

Figs. 135 and 136 show, in modified Goodman type diagrams, the influence of steady stress on alternating stress strength.

Items 52-53

Approximate S-N curves for magnesium alloy J-1 are given in Fig. 137.

Ref. 4

Items 54-61 Ref. 67

These tests on three magnesium alloys, FS-la, J-l, and O-l, were made to show the difference in fatigue strength of the alloys caused by differences in the test methods. The individual specimen tests are plotted in Figs. 138-140. As a result of these tests the authors of the reference state that some magnesium alloys give appreciably higher strengths in rotating bending than in plate bending or in axial (push-pull) loading.

No S-N curves were given in the reference, but values of "Fatigue Limit, 107 cycles" were given. These are the values used in Table XII.

Items 62-63 Ref. 68

The tests on AZ81-T4 cast alloy were made "to compare the fatigue properties of AZ81-T4 with other similar magnesium alloys now in service". The reference concludes that "the unnotched fatigue strength of AZ81-T4 is approximately 4 ksi lower than AZ63-T4" and "the notched fatigue properties were practically identical to those of AZ63-T4". S-N curves are given on Fig. 141.

Items 64-69 Ref. 69

The tests on HM-31 forged alloy are plotted on Fig. 142 together with "results of previous testing on annealed HK-31 magnesium alloy". The values shown on the figure are based on stressing from zero to tension (A = 1.0). In addition to the tests plotted, "a limited number of the specimens were also tested in completely reversed loading", with the following results:

- At room temp., stress 15 ksi, one specimen failed at 2,085,500 cycles and one specimens failed at 3,875,000 cycles.
- At 500°F, stress 12 ksi, one specimen failed at 91,700 cycles. stress 9 ksi, one specimen failed at 1,102,300 cycles.
- At 650°F, stress 7 ksi, one specimen failed at 1,100,900 cycles after having survived 108 cycles at 10 ksi at 500°F.

Items 70-74 Ref. 70

These tests of HM-21 forged alloy were "preliminary", - for comparison with HM-31 alloy. S-N curves are shown on Fig. 143.

SECTION VI. TITANIUM ALLOYS

6.1 General

It is interesting to note that in Table XIII the fatigue strengths of smooth titanium alloys run close to, and sometimes exceed, fifty percent of the tensile strengths. A few data (items 67 to 86) are given on high temperature properties.

6.2 Discussion of Data in Table XIII

Items 1-6

Ref. 71

Alloy RC-55 Type. Reduction in endurance limit of smooth specimens, item 5, is charged to the heating effect resulting from high speed cycling, when opm are increased from 1,800 to 10,000. The fact that notched specimens, item 6, showed little effect from speed, and did not heat up, is thought to be because of the relatively small volume of material subjected to maximum stress and the ability of surrounding material to conduct the heat away as fast as generated.

Fig. 144 shows the S-N curves for this alloy. It is to be noticed that the curves are based on small numbers of specimens. The total number of specimens for each curve is noted on the figure.

Items 7-14

Ref. 72

The reference refers to earlier tests on Rem-Cru sheet 0.060" thick, tested in Krouse sheet fatigue machines, and remarks: "The fatigue values were higher in the transverse direction than in the longitudinal direction for all conditions. No completely satisfactory reasons could be given to account for the annealed and pickled samples producing the best results and the cold rolled specimens the poorest results. The tests reported in reference 72 were made to study further some of the problems referred to above.

The variability of Ti-alloys appears in an analysis of the static properties as reported in reference 72:- (Standard deviations have been computed from the data in the report.

Alloy	uts	ST.	YP	St.
	ksi	DEV.	ksi	DEV.
T1-150A *	143.0	5.9	127.6	6.0
RC-130B	153.6	3.2	147.1	5.2

Reference 72 says: "These melts were early experimental ones and consequently were not of comparable quality to melts produced at present".

The following excerpt is quoted from subject report:

ABSTRACT

"The evaluation of the effects of various treatments on the fatigue properties of titanium bar stock alloys Ti-150A and RC-130B was made. The various treatments of Ti-150A and their corresponding fatigue endurance limits are as follows:

- Machined and polished 68,000 psi
 Ground 63,000 to 70,000 psi
 Ten percent permanently stretched and ground 54,000

psi (wide scatter of data)

4. Ground and scaled - 56,000 psi 5. Machined notched - 40,000 psi 6. Ground and notched - 21,000 psi

The fatigue strength varied from about 35 to 45 percent of the tensile ultimate strength for the different treatments, except for the notched condition as would be expected. RC-130B gave endurance limits of about 67,000 psi (approximately 45 percent of tensile ultimate strength) for the ground, unnotched condition, and about 24,000 psi for the ground notched material. The wide range of values for the ground Ti-150B alloy and for the 10 percent stretched and ground Ti-150A alloy may have been due to various degrees of surface cold work, and surface discontinuities, caused by grinding and cold work. In addition, radiography identified tungsten inclusions which were probably a contributing factor. In general the surface treatment has a marked effect upon the fatigue strength of titanium and its alloys. For the conditions tested, a machined and polished surface produced the optimum fatigue properties."

Fig. 145 shows the evidence upon which the discussion of items 7 to 14 is based. The high degree of scatter must be considered in connection with the values stated for "fatigue endurance limits".

Item 15

Ref. 73

These tests of RC-130B titanium alloy were run to provide data for a study of the statistical nature of the material. In the reference report the data are analyzed by using the means of the reciprocals of the life cycles. In Fig. 146, the P-S-N (Probability-S-N) curves were established by probit analysis (reference 29).

Items 16-40

Refs. 74,75

The values of Se for 107 cycles that appear in the data tables were scaled from curves in the references. These values are listed as "plus-orminus" values to indicate that they are not highly precise in the second significant figure. In general only three or four - sometimes five - specimens were tested at any one stress level.

Items 41-44

Ref. 76

These items show the sensitivity of the nearly pure titanium, Ti-75A, to heating under high speed cycling, and to extremes of speed, that is, from 400 RPM to 10,000 RPM. The reference says, however, that "specimens which were water cooled to dissipate the internal heat showed small spread in the failure curves for the different speeds of testing that were studied". Fig. 147 shows S-N curves for these items. Values of Se in Table XIII were scaled from Fig. 147.

Items 45-62

Ref. 77

In these tests of titanium-chromium-molybdenum alloys, 20 specimens were used in tests for each value of Se. For the data in Table XIII, static properties excepting UTS were scaled from graphs in the reference. In their Summary, the authors refer to Fig. 148 and say: - "The fatigue endurance limit of the alloy appears to be unchanged, regardless of alloy content, although the tensile strength is greatly increased as a result of alloy content".

Items 63-64

The two S-N curves for 6 Al-4 Va titanium alloys shown on Fig. 149 represent tests run to "illustrate the improvement in endurance strength which can be realized using duplex heat treatments".

Item 65

Ref. 29

Ref. 78

The S-N curve for 6 Al-4 Va titanium alloy shown on Fig. 150 is based on tests of 63 specimens, whereas the lower curve of the same material shown on Fig. 149 is based on 8 specimens, only four of which broke at less than 108 cycles. Whether or not this alloy has an "endurance limit" at around 107 or 108 cycles is questionable.

Item 66

Ref. 38

The reference says of the S-N curves for 6 Al-4 V titanium alloy bar from which Fig. 151 was derived that they show "some limited axial . . . fatigue data". The scale of stresses on Fig. 151 should be read carefully. They indicate the steady stress component as well as the vibratory component of stress, and it should be noted that the steady stress increases as the alternating stress increases.

Items 67-86

Ref. 79

These tests of 7 Al-3 Mo titanium alloy were made to study the effect of ageing versus annealing treatments on the high temperature creep and fatigue properties of the alloy. The S-N curves, Figs. 152 and 153, were derived from curves given in the reference. The stress scales on the figures show the steady stress component and the alternating stress component.

SECTION VII. MISCELLANEOUS MATERIALS

7.1 General

The data in Table XIV apply to plastic and wood laminates and a few metallic materials. Some data on high temperature properties of beryllium are included.

7.2 Discussion of Data in Table XIV

Items 1-2

Ref. 8

The Ingot Iron used for item 2 was specially treated "to retain as much carbon and nitrogen in solid solution as possible". This treatment was used to render the iron more susceptible to "coaxing" under fatigue stressing, so that the effect of coaxing on Prot tests could be investigated.

Items 3-4

Ref. 4

In the case of this gray (cast) iron, the plots of individual test results as given in the reference warrant the drawing on Fig. 154 of a single S-N curve to represent both the smooth and the notched specimens.

Items 5-6

Ref. 29

For the aluminum-nickel bronze, Item 5, 76 specimens were tested to give the S-N curves shown on Fig. 155. For the beryllium-copper, Item 6, 66 specimens were tested for the S-N curves on Fig. 156. The values of Se given in Table XIV are probably higher than would be shown for longer cycle life.

Items 7-17

Ref. 80

S-N curves for these glass-fiber-reinforced plastic laminates are given on Figs. 157, 158. The strength reduction factor of these notched laminates is noticeably smaller than that usually found in metals, and in the case of the laminate with a glass mat, items 14-15, is actually less than unity.

Items 18-23 Ref. 80

These items, showing the effect of superimposed mean (steady) stress, are shown as S-N curves on Fig. 159. for a single laminate.

Item 24

This item, represented by the S-N curve on Fig. 160, shows the effect of stressing the glass-fabric-reinforced laminate at 45° with the direction of the warp. The effect of anisotropy can be seen by comparing this item with item 18.

Items 25-30

Ref. 80

S-N curves for these heat resistant glass-fiber-reinforced laminates are given on Figs. 161,162.

Item 31

Ref. 42

An S-N curve for this glass fabric laminated plastic is given on Fig. 163. The curve is considerably different in character from most of those on Figs. 157 to 162 although the long life fatigue strength is consistent with those of the other laminates. The specimens were round instead of flat, the stressing was in bending instead of being axial, and the resin was not identical with those used for the other laminates. The reference says:- "The decrease in fatigue strength value with increasing number of cycles is relatively small".

Items 32-47 Ref. 81

Values of S_e for these tests of yellow birch and hard maple, both solid and laminated, were scaled from Fig. 164 for 10° cycles. It must be remembered that these values are "mean" strengths of laboratory-size specimens. The "scatter" in data cannot be determined since each S-N curve was based on somewhere between half a dozen and a dozen and a half specimens. The reference points out that the "endurance limit" for these woods is apparently below the 10° cycle strength, and there is no indication in the tests of how far below.

A variable not listed in the tabulation is "moisture content". The reference gives 7 or 8% by weight for the natural woods, and 1.6 to 3.5% for the compressed laminates. The reference says "it is believed that no serious change in moisture content occurred during the test".

One respect in which the data in the last eight items differs from values for steel is in the effect of increased speed of cycling. There is a small but persistent decrease in fatigue strength as speed increases from 3450 to 10,600 cpm. Steels have not been found so sensitive at these speeds, and for much wider differences have shown the opposite effect.

Items 48-49 Ref. 82

Data for these flat-plate bending tests of solid and laminated wood specimens are given as percents of the static modulus of rupture "because specimens of the same species from different trees will vary considerably in strength". Test results are shown on Fig. 165 as a "scatter band" since the separate test values for the two solid and the two laminated woods were completely intermingled on the figure in the reference. This is consistent with the statement in the reference:— "Since the shear stress is relatively low compared to the fiber stress in bending, it has been found that plywood specimens tested as cantilever beams subjected to repeated or reversed bending stress, with the plane of the veneers perpendicular to the load and the grain of the outside plies parallel to the span, will fail in the wood before separation of the veneers occurs".

The average value, 27% of static modulus of rupture, is given for 50,000,000 cycles, and the reference points out that the slope of the S-N curves is still negative, indicating that this is not the "endurance limit" of the woods tested.

Item 50 Ref. 83

The S-N curve, as based on four specimens, is shown on Fig. 166.

Regarding other data on beryllium, the reference states that other investigators have reported "the fatigue strength under direct stress of hot pressed, warm extruded Beryllium to be 31,300 psi at 10° cycles", and the "fatigue strength of Beryllium under cantilever bending . . . as 32,000 psi". Also, it quotes another set of tests as showing that strip specimens under direct stress showed "an endurance limit at 10° cycles of 22,000 psi".

Item 51 Ref. 84

The 1100°F stress-rupture data for Brush QMV Beryllium are plotted on Fig. 167.

WADD TR 60-42

The axial test data for Brush QMV Beryllium given by the reference are plotted on Figs. 168-170. Fig. 168 shows room temperature tests and Figs. 169, 170 show tests at 1100°F. Each of the S-N curves shown is based on a small number of specimens. The data in Table XIV were read from the S-N curves.

TABLES, pp. 28-137

ILLUSTRATIONS, pp. 138-267

BIBLIOGRAPHY, pp. 268-273

LIST OF AUTHORS OF REFERENCES, pp. 274-275

LIST OF MATERIALS, pp. 276-278

T			- 									Γ			
	Specimen	Surface Finish	k/o and Electro- Polish		Ground, Electro- Polish	erit.		Lapped			•	*	•		•
	eds	Sise	0.200"	8	0.220*	9*.90	0.584" #	0.220"						•	•
	8	Speed	1800	8	806	1500#	8	10,000	*		*		ŧ	8	8
	Testing Machine	Kind of Test	Push- Pull		Bot. Bend.	Rot. Cartil.	8	Rot. Bend.	t		*	=			t
4335	2	Type	Somtag		R.R. Moore			R.R. Moore	*	=	=	8			•
SAE Steels 1008 to 4335		Life, Cycles	701	2	8	2(101)		7οτ	8	=	2	2	E	=	E
S Stee	pert1e	g.	•	ţ			ł	i	į	i	į	1	i	ł	ł
	Fatigue Properties	Ke Se	***	184	17±	35.5	13.0	39.3	85.88	43.5	27.2	33.2	86.0	37.7	88
Table I.	Fatig	S Z	<u>o</u>			<u>e</u>	2	Q.		=	E				
취		3	1.0	t		1.0	3.9	1.0	8.8	1.0	2.2	1.0	8	1.0	S. S.
		tion	Grain Size ASTM 7-9.	Grain Size AFIM 3-5.		Smooth	60° V-noteh R = 0.010"	Smooth	60° V-notch R = 0.015"	Smooth	60° V-notch R = 0.015"	Smooth	60° V-notch R = 0.015"	Smooth	60° v-notch R = 0.015"
		Description	SAE 1006 Steel.	SAE 1008 Steel. Decarburized	ŧ	1020 Steel.	•	Hot-Rolled 1040 Steel.	r	E	2	Cast 1040 Steel. Smooth	r	•	*
		Ref	м	:	*	#	3	2	2	=	:	:	*	2	*
		Item	н	a	m	#	~	9	2	90	٥	ខ្ព	ជ	ង	13
WA	DD '	TR 60)-42			L		28							

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		Bost Trestment	Received as hot-rolled rod. No special heat trestment.	Decarburized in water saturated hydrogen at 140°F:- 100 hr. et 1725°F, followed by 100 hrs. et 1290°F.	\$			Aumealed 1650°F.	=	Hormalized 1650°F, Tempered 1200°F.	=	=	=	=	t
SAE Steels 1008 to 4335 (Continued)		Chemical Composition	C-0.09, S1-0.14, Mn-0.46, P-0.010, S-0.027, Cr-0.08, T1-0.01, Mo-0.01, M1-0.07, Cu-0.05	c-0.003/0.005, 81-0.14, Mn-0.46, P-0.010, s-0.027, cr-0.08, T1-0.01, Mo-0.01, H1-0.07, cn-0.05	*	c-0.15/0.25, 180-0.3/0.6, s-0.055, P-0.45	£ .	C-0.39, Mn-0.82, 81-0.28, P-0.020, 8-0.037	Ε	E	**	C-0.39, Mn-0.78, 81-0.47, P-0.023, S-0.039		£	•
Table I. S.		Hard.	RB 62-64	RE 67-70	=		;	149 149	*	170	2	156	£	187	=
Tab1	rties	R.A.	71.9	85	r	60.5	2	9 .4 .6	t	58.3	2	1.94	=	52.2	E
	Static Properties	Elong.	36	47.5 1"	2	W.20	Ł	## ##	\$	26.5	t	27.5	=	24.5	•
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WAD	D T	R 60-	-42					29							

	Specimen	Surface Finish	Legged	•		•		•	Legped		2		Pol 1sh		ŧ
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	Testing Machine	Kind of Test	Rot. Bend.	B		2 .			Rot. Bend.			•	Rot. Bend.	t	t
(g	Tee	fype	R.R. Moore	s		ŧ	8		R.R. Moore	*	*	*	R.R. Moore	z.	
SAR Steels 1008 to 4335 (Continued)		Life, Cycles	107	8		*	*	\$	107	8	ŧ	E	⁷ ot	2	2
to 433	Fatigue Properties	Bt. Der.	ł	ļ	•	;	į	1	1	1	;	į	•		ļ
1008	1 ag	S ta	4.8 4	31.7	41.7	31.2	58.5	37.3	78.7	33.0	4.89	36.3	901	105	101
Steel	Peti	Rail Est	<u>R</u>			t	*	r	2	=	•	E	<u>¥</u>	±	=
		3	1.0	oi oi	1.0	8	1.0	2.2	1.0	8.	1.0	8.8	1.0	E	8
Table I.		Description	Cast 1330 Steel. Smooth	60° V-notch R = 0.015"	Smooth	60° V-notch R = 0.015"	Smooth	60° V-notch R = 0.015"	Smooth	60° V-notch R = 0.015"	Smooth	60° V-notch R = 0.015"	2315 Carburized Steel Core Bun 363. Carb. depth 0.040"-0.044". Grain Size ABIM 2-5.	2315 Carburized Steel Core Ebn 341. Carb. depth 0.040"-0.044". Grain Size ASTM 2-5	2315 Carburized Steel. Core En 187. Carb. depth 0.040"- 0.044". Grein Size AFIM 2-5.
		Des	Cast 1330 S	z		•	E	.	Hot-Rolled 1340 Steel.	*		8	2315 Carbur Core Bhn 36 0.040"-0.04 ABIM 2-5.	2315 Carburized Steel Core Bhn 341. Carb. d 0.040"-0.044". Grain ASTM 2-5	2315 Carbur En 187. Car 0.044". Gra
		Bef.	8			*		£	=	E	#	F	9	#	t
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IAW	ני סכ	r 60	42						30						

		Heat Trestment	Hormalised 1650°F, Tempered 1200°F.		Hormalised 1650°F, Tempered 800°F.	•	Quenched 1550'F. Tempered 1150'F.	=	Hormitsed 1650°F, Tempered 1200°F.	•	Quenched 1525 F, Tempered 1200 F.	•	Carb. 1650°F, 6 hrs., 0Q; Temp. 300°F.	Carb. 1650°F, 6 hrs., 003 1375°F after carb.	Carb. 1650°F, 6 hrs., 0Q; 1330°F after carb.	
SAE Steels 1008 to 4335 (Continued)		Chemical Composition	C-0.31, Nn-1.64, S1-0.47, P-0.015, S-0.022	Ε	C-0.30, Mn-1.50, 81-0.42, P-0.031, 8-0.043	*	c-0.31, Ma-1.64, 81-0.47, P-0.015, 8-0.022	E	c-0.38, 142-1.68, 81-0.35, P-0.020, 8-0.025	ε	E	E .	C-0.15, 14n-0.54, P-0.025, 8-0.021, 11-3.68	2	E	
Table I.		Hard.	Ehn 201	Ŧ	507		569	=	Ban 207	•	569	=	Re 59-61	89-09	59-61	
	ties	R.A.	58.5	E	58.5		55.6	=	60.1	=	6.09			ł	•	
	Static Properties	Elong.	24.0	r	96.0		20.5	#	23.5	=	2.5	z		i	į	l
	Stati	ks 179	61.5	E	63.5		106.0		56.8	E	106.9	t	겨	149	130	
		urs kei	99.3	E	97.0	:	28.2	r	101.8	2	121.2	E	88	893	187	
		Item	#	भ	ዻ	17	82	139	ଷ	ส	83	83	₹	80	%	
WADD	TR	60-	1 2						31							

Table I. SAE Steels 1008 to 4335 (Continued)	Fatigue Properties Testing Machine Speciasa	Kt Sm Se St. Liffe, Type Kind of Speed Size Surface kei kei her. Cycles Test cym Pinish	1.0 No 98.5 10 ⁷ R.R. Rot 0.250" # Polish 2-5			" 120t " " " " " " " " " " " " " " " " "	3.1 " h2t 8ee 71g. 9	305	394	1.0 Ho 133 10 ⁷ R.R. Rot 0.250" \$ Polished to 5-7	rth 157 " " 157 " " 157 " " 157 " " " 157 " " " 157 " " " 157 " 157 " 15	reb. " " 1347 " " " " " " 15-7 " " 15-7 " " " 15-7 " " " " 15-7 " " " " 15-7 " " " " 15-7 " " " " 15-7 " " " " " " 15-7 " " " " " " " " " " " " " " " " "	3.1 " Wht " " " " Bee Fig. 9
(Tes	Tee	e e	R.R. Moore		=		*	•	8	R.R. Moore	2		t
35 (Contin		Lifte, Cycles	Tot	•	8	*	8	•		107	*	8	8
to 43	pertie	à à	1	!	ţ	:	•	i	•	i	i	i	i
100	gue Pro	g g	98.5	021	भ	1204	ğ	ă,	\$	133	157	741	#
8 Stee	Patt	8 7 1 7	<u>Q</u>				2		=	<u>2</u>		*	
		¥	1.0		B	3	3.1 3.5	*	2	1.0	*	t	3.5
Table I.		Description	2315 Carburised Steel Core Bin 197. Carb. depth 0.032. Grein Sise ASES 2-5	2315 Carburised Steel Core Bhn 341. Grain Sise AGDE 2-5	2315 Carbarized Steel Core Bhn 341. Grain Sise AGDE 2-5	2315 Carburised Steel	2315 Carburised Steel Core Bhn 363. Grain Sise ASTM 2-5. Notched	2315 Carburised Steel Core Bhn 341. Grein Size ASTM 2-5. Notched	2315 Carburised Steel Core Bhn 187. Grain Sise ASTM 2-5. Notched	2330 Carburised Steel Core Bhn 514. Carb. depth 0.031". Grein Sise ASEM 5-7	2330 Carburised Steel Core Ban 395. Carb. depth 0.0k1". Grain Sise ASIM 5-7	2330 Carburized Steel Core Ebn 514. Carb. depth 0.030". Grein size ASTM 5-7	2330 Carburised Steel Core Ban 321. Grain Sise ASTM 5-7. Notched
		Bet.	9		2		8	•	*				8
		It is	12	88	&	ይ	ಇ	8	33	#	£	 %	37

		Heat Treatment	Carb. 1650'F, 6 hrs., 0Q.	Carb. 1650°F, 6 hrs., 00; 1475°F, 0Q; Temp. 300°F.	Carb. 1650°F, 6 hrs., 0Q; Furnace 1875°F, 0Q.	Carb. 1650°F, 6 hrs., 0Q; Surface Polish, Rebest in Cyenide, 1475°F, 0Q, Temp. 300°F.	Carb. 1650'F, 8 hrs., 00; feet. 300'F.	Carb. 1650°F, 8 hrs., 00; Furnace 1375°F, 00; femp. 300°F.	Carb. 1650°P, 8 hrs., 00; Beheat 1330°P, 00; Temp. 300°P.	Carb. 1650°F, 3 hrs. to fursees 1375°F, OQ: Temp. 300°F.	Carb. 1650'F, 6 hrs., 00; 1375'F, 00; Temp. 300'F.	Carb. 1650°F, 3 hrs., 04, 1375°F, 04; Yeap. 300°F.	Ourb. 1650'r, Oq. Rebest1375'r,
SAE Steels 1008 to 4335 (Continued)		Chemical Composition	C-0.15, Mn-0.54, P-0.025, 8-0.021, M1-3.68	ŧ	ŧ	ŧ	C-0.18, Ma-0.48, P-0.025, S-0.017, M1-3.58	•	8	C-0.31, Ma-0.70, P-0.025, B-0.023, M1-3.31	ŧ	•	
Table I.		Hard.	19-09	19-09	60-61	•	59-61	89-69	59-61	% %	8	63	8
	ties	R.A.	1	•	ŀ	•	i	•	•	1	į	į	•
	Static Properties	Elong.	1	i	ł	•	;	i	ļ	i	:	ł	
	Stat1	E ta	130	187	187	į	걲	149	130	173	\$	%	345
		UTE	198	88	%	ļ	88	88	187	38 2	Ŋ	88	8
		Item	12	88	&	&	ಸ	×	æ	ま	83	%	37
WADD	TR	60-4	2		···-			33		· 			

								-									
	Specimen	Burface Pistsb	Polished		•	*		; ;		Lapped	•		8	8	•	•	
	•dg	Bire	0.25" 6		o.ors.			*	•	0.220"					•		t.
	*	Speed	3600	*	1500		\$	8	*	10,000		*	*	*	*		E
	Testing Machine	Kind of Pest	Rot. Bend.		Actal					Rot. Bend.	•		•	k			•
(per	Tee	Type	R.R. Moore		Krouse		*			R.R. Moore	*	8	3				8
SAE Steels 1008 to 4335 (Continued)		Life, Cycles	701		107	*			•	107	8			8	2		E
to 43	Patigue Properties	9 g.	8 8 9	•	i	į	ł	;	-	ł	į	i	i	i	į	į	1
16 1006	ne Prog	2 Ta	8	82	1.4	36	23	켞	93	51.2	33.3	61.3	40.6	62.0	31.2	87.4	41.2
3 Stee	Patig	Se A	<u>Q</u>	=	욡				=	•			=	=		*	E
1 11		¥	1.0	Yes	1.0	1.5	2.0	4.0	5.0	1.0	8.0	1.0	2.5	1.0	2.5	1.0	2.5
Table I.		tion	Smooth	Semi-circ. notch. R = 0.050"	Smooth	Notched		8	**	. Smooth	60° V-notch R = 0.015"	Smooth	60° V-notch R = 0.015"	Smooth	60° V-notch R = 0.015"	Smooth	60° V-notch R = 0.015"
		Description	2340 Steel.	•	SAE 4130 Steel.	8				Cast 4135 Steel. Secoth	t	E	E	Hot-Rolled 4140 Steel.			5
		Ref.	80	3 .	6	9	:			5		8	¥	E			
		1tem	38	39	Q ₁	141	ð	† 3	4	St	2	24	84	64	ይ	な	×
WAI	י סכ	rr 60)-42						3	4							

		Boot Trestment	1450°F, 30 min., 00; Sugger 1200°F, 1 hr.	*	Horselised.	8	8	•	•	Hormalized 1650°F, Tempered 1200°F.		Quenched 1550°F, Tempered 1175°F.		Mormalized 1650°F, Tempered 1200°F.	8	Quenched 1525°F, Tempered 1150°F.	\$
SAE Steels 1008 to 4335 (Continued)		Chemical Composition	C-0.40, Ma-0.74, P-0.019, S-0.20, S1-0.28,	•		-	-			C-0.37, Na-0.82, 81-0.45, P-0.035, S-0.027, Cr-0.88, No-0.19		E		C-0.39, Mn-0.84, 81-0.28, P-0.019, S-0.029, Cr-0.96, Mo-0.19	E	E	2
Table I.		Hard.	28	2	1	i	i	ŀ	i	83	E	317	E	223		д	
	ties	R.A.	64.8			!	ł	i	;	43.1		35.8	=	68.9		60.1	E
	Static Properties	Flong.	26.5		14.2		E	£	=	18.0		14.0	=	23.4		18.5	
	Static	rr Kei	8.1		98.5			=	=	86.5	ŧ	131.0	=	86.1		133.0	ŧ
		UTB ks1	112.9	•	LTI	111			=	112.7	2	4.6 4ር	=	111.1	=	146.8	
		Item	&	39	2	돠	궟	£4.	\$	54	3	24	82	64	22	13	જ
WAD	D T	r 60.	-42							35	i						j

	Specimen	Surface Finish		į					•	Mach. Polish		Mach. Politab	8 8 8
	8	8150	3/16" × 12"	0.230" \$	2	5	5	E	•	ø.₁88r.o		*	.
		Speed cps	1725	1							1 1 1		
	Testing Machine	Kind of Test	Reversed Cant. Bend.	Rot. Bend.	•	•			8	Rot. Bend.	•	x	•
(peg	To	Type	Krouse	R.R. Moore				*	* ·	•		•	
SAE Steels 1008 to 4335 (Continued)		idfe, Cycles	Tot	Tot	*	2	s		2	107	£	E	r
8 to 43	erties	St. Dev.	1	i	i	ł	i	ŀ	i	•	ł	ł	8 8 1
200	Fatigue Properties	Se Kei	r L	ส	8	æ	%	88	æ	83‡	6 5 ‡	\$16	55±
8 Stee	Petigu	Ket Ket	<u>Q</u>	2				x	*	욡		•	ŧ
i 11		ž.	1.0	8.	*	*	2.6		t	1.0	8.0	1.0	8.0
Table I.		Description	Specimens to rolling.	This test . 60 V-notch,	4320 Steel. Mitrided 975°F, 8 hrs., 0.004-0.005" depth. 60° V-motch, 0.002" R.	4320 Steel. Mitrided 975°F, 15 hrs., 0.008" depth. 60° V-notch, 0.002" R.	Mitrided. 60 V-notch, 0.010" R.	4320 Steel. Mitrided 975°F, 8 hrs., 0.004-0.005" depth. 60° V-notch, 0.010" R.	h320 Steel. Mitrided 975°F, 15 hrs., 0.008" depth. 60° V-motch, 0.010" R.	Smooth	60° V-notch, 0.038" Deep, R = 0.0007"	Smooth	60° V-notch, 0.038" Deep, R = 0.0007"
		Desc	4320 Steel. Transverse to	4320 Steel. 7 Not Mitrided. 0.002" R.	4320 Steel. 8 hrs., 0.00 60° V-notch,	4320 Steel. 15 hrs., 0.0 60° V-notch,	4320 Steel. Mitrided. 60 0.010" R.	4320 Steel. 8 hrs., 0.00 60 V-notch,	4320 Steel. 15 hrs., 0.0 60° V-notch,	V-modified 4330 Steel	t	t	ŧ
		Ref.	า	ឌ	*	ŧ	*	*	*	13	2	*	5
		Item	53	杰	55	%	57	%	59	8	હ	8	63
WAI	DD 1	R 60	-42				36						

		Boot Treetment		Horm. 1600°F, %5 min., 30 sec. delay, 0q; 1600°F, %5 min.; Temp. 1060°F, 1.5 hrs.; Stress Believe 1060°, 1 hr.		•	*	ŧ		1660°F, OQ; Tempered 270°F.		1660°F, 0Q; Tempered 400°F.	2
SAE Steels 1008 to 4335 (Continued)		Chemical Composition	C-0.22, Mn-0.85, 81-0.30, 8-0.015, P-0.018, Cr-1.09, H1-2.10, Mc-0.33	C-0.17, ND-0.84, S1-0.41, S-0.018, P-0.012, CT-0.97, N1-2.04, NO-0.43	2	8	E			C-0.32, Ma-0.88, P-0.012, S-0.018, S1-0.26, N1-1.79, Cr-0.84, Mo-0.355, V-0.07	ŧ	t	- *
Table I.		Hard.	Dph 310-346	1	ł	i	;	į			!	ļ	1
	ties	R.A.	•	leved 81.)		*		ŧ		5 64	*	2 54	•
	Static Properties	Flong.	15	(UNS not given. Believed to be about 140 ksi.)	*	*		*	ŧ	174		171	.
	Static	Es 13	130	be abox				*	*	177‡		1972	
		UES kei	τψτ	(UTS 1	8.	=	8	*	×	£9 2	*	820	2
		Item	53	ま	55	.%	57	ଝ	59	99	જ	88	63
WAI	נ סס	r 60	-42						3	7			

	_															
	Specimen	Burface Finish	Mach. Polish	ŧ		1 1 1	k micro- in.	•	*	•			legged	•		•
	Bpe	8120	0.188" #	•		•	0.223" •					t	0.220"			*
	•	Speed		!			8,000	8	3	*		8	10,000	z.	:	8
	Testing Machine	Kind of Test	Rot. Bend.	ŧ	8	•	Rot. Centil.	•		•	F	s	Rot. Bend.		*	•
(Fig.	Tes	Type			1		Krouse	*	ŧ	E	ŧ	E	R.R. Moore	*	8	t
SAE Steels 1008 to 4335 (Continued)		Life, Cycles	107	3	1	8	Prot	.		8	2	E	101	8		*
to 43	erties	St. Dev.	i	;	ł	1	4.4	5.6	4.6	9.3	3.5	5.9	ţ	i	ì	
1006	Fatigue Properties	Se ks1	93‡	#2	8#t	6.5±	4.88	83.2	4.88	4.58	4.1	91.6	63.0	34.9	9.11	18.2
Bte.	Fatig	Red Red	욡	=	r	*	윷	•	t	x	*	2	SE SE			
1 11		¥	1.0	1.0	1.0	8.0	1.0	£	*	E	=	2:	1.0	2.2	1.0	8
Table I.		Description	Smooth	Smooth	Smooth	60° V-notch, 0.038" Deep, R = 0.0007"	Longitudinal	fransverse Same heat as Item 68.	Longitudinal	Transverse Same heat as Item 70.	Longitudinal	Transverse Same heat as Item 72.	seel. Smooth	60° V-notch R = 0.015"	Smooth	60° V-noteh R = 0.015°
		Девс	V-modified 4330 Steel.	r	E	T	4330 Steel.	2	E	t		P	Cast 4335 Steel. Smooth	£	ŧ	2
		Ref.	ET.	ŧ	*	2	14	*	*	E	8	8	5	ŧ	ŧ	*
		Item	đ	જ	8	<i>19</i>	8	8	20	r	22	ಬ	74	5	76	ш
WA	י מס	TR 60)-42	· · · · · · · · · · · · · · · · · · ·				3	.8							

		Heat Treatment	1660°F, 0Q; Tempered 500°F.	1600°F, OQ; Tempered 650°F.	1600°F, 0Q; Tempered 800°F.	1600°F, OQ; Tempered 800°F.	Salt bath 1550°F, 15 min., OQ; Tempered 30 min. to RC &1±2 on 13/32" \$	ŧ			ŧ	•	Normalized 1650°F, Tempered 1125°F.	•	Quenched 1525°F, Tempered 1025°F.	
SAE Steels 1008 to 4335 (Continued)		Chemical Composition	C-0.32, Nn-0.88, P-0.012, S-0.018, S1-0.26, N1-1.79, Cr-0.84, No-0.355, V-0.07	E	t	**	c-0.33, Mm-0.69, P-0.015, S-0.023, S1-0.029, N1-1.72, Cr-0.80, Mo-0.32, V-0.18	Z.	C-0.34, Ma-0.67, P-0.014, S-0.013, S1-0.26, N1-1.80, Cr-0.90, Mo-0.33, V-0.18	Ε	C-C.31, Mn-O.68, P-O.013, S-O.017, S1-0.29, N1-1.80, Cr-O.84, Mo-O.32, V-O.18	E	c-0.34, Mn-0.60, S1-0.49, P-0.034, S-0.036, Cr-0.70, N1-1.74, Mo-0.30	F	c-0.34, Mn-0.60, S1-0.49, P-0.034, S-0.036, Cr-0.70, N1-1.74, Mo-0.30.	*
Table I.		Hard.	•	į	ļ	•	Rc 43 Long.	42 Trens.	42 Long.	43 Trans.	43 Long.	43 Trans.	393	=	Bhn 375	E
	ties	R.A.	55±	57±	55±	=	94 Jong.	32 42 Trans. Trans	146 Long.	39 Trans.	52 Long.	38 Trans.	50.3	E	17.8	E
	Static Properties	Elong.	164	164	164	E	11.0 Long.	8.0 Trans.	10.5 Long.	9.5 Trans.	12.7 Long.	9.0 Trans.	14.5	E	9.5	I.
	Stati	YP ks1	195‡	1904	185±	=	194 Long.	180 Trans.	193 Long.	199 Trans.	210 Long.	206 Trans.	100.5	E	155.9	E
		UTS ksi	236	82	201	ŧ	205 Long.	197 Trans.	199 Long.	209 Trans.	214 Long.	214 Trans.	126.5	=	168.2	:
		Item	₫	65	8	67	88	8	٤	r.	22	ಬ	杜	72	92	71
WADI	TR	₹ 60-	42				,		39					_		

ł		8 5	•	•										
	Specimen	Surface Finish		1	2/0	*	2	*	*	£			•	t
	Spec	Sire	0.500"x 0.300"		1/8" \$	ø "4\£	1/5" 🏚	1. 9	1 3/4"\$	1/8" \$	1/4" \$	1/2" 🍎	ı. •	1 3/4"\$
		Speed	7,650 ±	ŧ	2,100	3,600	001,1	ŧ	380	2,100	3,600	1,100	5	380
	Testing Machine	Kind of Test	Bending	æ	Rev. Bend. Const. Force	=	r	E	=	Ξ	τ		ŧ	E
1350	Pe	Type	GE Vib.	E	Rot. Cant.	*	r	=		E	E	E	E	r
SAE Steels 4340 and 4350		Life, Cycles	25(107)	E	3(107)	2	8		1.2(107)	3(107)	E	=	E	1.2(107)
Steels	erties	St.	7.1	2.5	1	į		;	***	1	į	•	1	ļ
SAR	Fatigue Properties	Kg 1	89.7	57.4	82.5	81.0	78.0	74.0	74.0	51.7	₩8.0	9.8. 0	n€.0	0°21
Table II.	Fatigu	8 2 E	S.	2	SK SK	E	=	E	E	r.	z	=	E	E
व्य		Ž,	1.0	:	7.0	r	:	±	ŧ	2.0	=	#	E	2
		Description	4340 Steel. Tests stopped at "incipient fracture". Microstructure, ferrite & tempered martensite.	4340 Steel. As above, except micro-structure was ferrite & fine spheroidite.	4340 Steel. Failure - visible crack.	F	: :	E E	n n	4340 Steel. Notch,-semi- circ. groove, R = 0.01". Failure - visible crack.	4340 Steel. Notch,-semi- circ. groove, R = 0.02". Failure - visible crack.	4340 Steel. Notch,-semi- circ. groove, R = 0.04". Failure - visible crack.	4340 Steel. Motch-semi- circ. groove, R - 0.08". Failure - visible crack.	4340 Steel. Motch, semicirc. groove, R = 0.14". Failure - visible crack.
}		Ref.	15,16	E .	17	£		2	£		:			.
f		it B	rl	cu .	m	4	2	9	7	8	0	10	я	വ 기

		Heat Treatment	1553°F 2 hrs., 0Q; 1067°F 16 hrs., 0Q.	1553°F 2 hrs., 0Q; 1112°F 16 hrs., 0Q.	1525°F 1 hr., 0q; 1010°F 1 hr., 0q(1).	•	•	•	1525 F 1 hr., 0q; 1000 F 1-1/2 hr., 0q.	1525°F 1 hr., 0Q; 1010°F 1 hr., 0Q.	£	E	F	1525°F 1 hr., 0Q; 1000°F 1-1/2 hr., 0Q(?).
SAE Steels 4340 and 4350 (Continued)		Chemical Composition	c-0.35, Mn-0.83, P, S, S1-0.27, cr-0.77, N1-1.82, Mo-0.37		C-0.385, Mn-0.78, P-0.010, S-0.018, S1, Cr-0.74, N1-1.80, Mo-0.25	=	=	=	E	E	E	£	2	2
Table II.		Eard.	38	28	36	ŧ	z	£	=	£	=	r	=	
61	rties	R.A.	55.2	62.2	55.6	=	E	F	z .	£	=	E	ŧ	.
	Static Properties	Elong.	17.6	27.5	16.1	=	ŧ	E	E,	E	E	E	=	E
	Sta	YP kei	153.7	83.1	156	=	=	E	=	E	:	E	£	E
		UTS ks1	167.8	103.5	1.63.7	=	=	:	t	E	=		ŧ	:
		Item	н	8	3	4	~	9	7	8	0	9	ជ	ผ

WAI			Table II.	1	E Stee	18 43h	O and 4	SAE Steels 4340 and 4350 (Continued)	Inued)				
ני סכ					Patig	ue Pro	Fatigue Properties		Ter	Testing Machine	g	Spec	Specimen
r 60	Item	Ref.	Description	Kt	S _m kei	Sekai	St. Dew.	Life, Cycles	Type	Kind of Test	Speed	Size	Surface Finish
-42	ជ	18,19, 20	4340 Steel. Notch- R=0.180" Se extrapolated, for Kt = 1.0, as 89 ksi.	1.20	No	72	;	701	Push- Pull	Axiel	1,800 or 40 to 120	0.400"¢	
	1	8	4340 Steel. Notch- R=0.180" Se extrapolated, for Kt = 1.0, as 93 ksi.	t	*	82	:	E	=	•	*	t	1
	25	£	4340 Steel. Notch- R=0.180" Se extrapolated, for Kt = 1.0, as 98 kmi.	2	t	82	ì	£	=	=	.	8	1 5 5 1
	91	ŧ	4340 Steel. Notch- R=0.180" Se extrapolated, for Kt = 1.0, as 118 ks1.	=	.	88	1	£	5	2	£	t	
42	71	23	4340 Steel. Longit. Specimens. Low RAT. Tested by Staircase Method, per ref. (2).	1.0	No	67.0	1.7	101	R.R. Moore	Roteting Bending		0.300"\$	Machine Polish
	81	:	4340 Steel. Transv. Specimens. Low RAI. Tested by Staircase Method, per ref. (2).	=	r	146.3	2.9	ε	r	r		:	E
	ନ	2	4340 Steel. Longit. Specimens. High RAT. Tested by Staircase Method, per ref. (2).	=	:	61.8	0,2	=	=	=	1	=	E
	&	E	h340 Steel. Transv. Specimens. High RAT. Tested by Staircase Wethod, per ref. (2).	ŧ	t	52.5	1.6	E	=	r		:	t
	ส	81	4340 Steel.	1.0	No	70	i	1.5(10 ⁷)	Schenck 20 Ton	Axial	2000 to 2500	0.400"	10 micro inch
	81	8	2	=	57.5	57.5	•	F	t	*	\$	*	.
	ଷ	8	2	=	821	80	•	E	t	Ε	E	=	E
				ļ									

### Static Properties UTS			Heat Treatment				1		Normal at 1700°F, Quench from 1525°F; 1170°F 10 hrs., Stress Relieve 1000°F 1 hr.	•			1525°F 1-1/2 hrs., Oq; Temper at 1150°F 1-1/2 hrs., AC.	ı	t
### Static Properties UTS	1 II		Chemical Composition				•			2	C-0.31, Mn-0.71, P-0.012, S-0.018, S1-0.28, Cr-0.74, N1-1.84, Mo-0.36		C-0.414, Mn-0.79, P-0.024, S-0.014, S1-0.029, Cr-0.77, N1-1.76, Mo-0.27	ŧ	ŧ.
Static Properties UTS YP Elong. R.A. 189.2 179.5 10.7 220 208 10.5 254.5 230 8.5 254.5 230 8.5 254.5 230 8.5 125 107 66.2 " " " 22.8 " " " 58.4 " " " " " " " " " " " " " " " " " " " " " " " "	rable II		Hard.	S S	4	24	25 %	Ж 54	1	ŧ	:	1	i	ì	l
UTS 199.2 179 189.2 179 189.2 179 188.5 196 1 158.5 19	•	rties	R.A.	1		!	ł		66.2	8.8	63.5	58.4	\$2.4	ŧ	.
UTS 19.2 179 189.2 179 189.2 179 188.5 196 158.5 196 1		ic Prope	Elong.	10.7	(1,1)	10.5	8.5	8.5	•	į	į	-	15.0 4D	=	E
		Stat	i	179.5	}	88	230	241	107	=	106	=	146.9 0.24	=	E
			UTS ks1	189.2	}	88	254.5	283	इ त	=	क्ष	=	158.5	=	E
क स्था भी			Item	73	?	큐	15	16	7.1	ъ В	19	8	ผ	83	33

Train Rect. Prest, Properties Prest, Prest,																				7
1840 1841 1842 Steels 1840 and 1830 (Corrillands) 1840 1841 1842 1841 1842 1841 1842 1841 1842		scimen	Surface Finish				2/0 Emery		•		1 8 8	!			! !	1		!	t 1	
The Ref.		æg	Size	0.400"	E	*	ø 11.0	0.13"6	1	!	! !	\$ 6 6 1	1				!		į	0.300"\$
Train Ref. Pascription Ref. Sq. Special high eard 4350 (Continued) Train Ref. Sq. Sq. Lidfe, Type Sg. Lidfe, Sg. Sg. Lidfe, Type Sg. Sg. Lidfe, Sg. Sg. Sg. Lidfe, Type Sg. Sg.		9	Speed cpm	2000 to 2500	E	Ħ	10,000	£ ,	3450 90	£	2	:	88	3450	E		880	•	£	10,600
Train Ref. Pascription Ref. Sq. Special high eard 4350 (Continued) Train Ref. Sq. Sq. Lidfe, Type Sg. Lidfe, Sg. Sg. Lidfe, Type Sg. Sg. Lidfe, Sg. Sg. Sg. Lidfe, Type Sg. Sg.		rting Machir	Kind of Test	Axtal	=	2	Reversed Bending	2	Rotating Bending	E		E	Axiel	Rotating Bending		I	Axtal	=	r	Rotating Bending
1.5 1.5	med)	Ter	Type	Schenck 20 Ton	:	æ	Cantilever		R.R. Moore	=	£	2	Schenck	R.R. Moore	=		Schenck	r	ŧ	R.R. Moore
Team Ref. Description Eq.	4350 (cont		Liffe, Cycles	1.5(10 ⁷)	=			*	701	*	ε	£	:	\$		£	F	=	*	101
Team Ref. Description Eq.	to end	perties	Bt. Dev.	ł	i		ł	!	•	ļ	i	ł	ł	į	ł	ļ	ł	ļ	ł	8.0
Team Ref. Description Eq.	els 43	ue Pro	Se kei	30	28.7	6.5	87±	38‡	ક્ટ	87	ಪೆ	92	2	45	£4	39	93	23	8	98
Team Ref. Description Eq.	AE Ste	Fetig	Sm ket	Š	28.7	150	S.		S.	Ł	=	ı	z	=	±	:	E	57	88	No
Item Ref. Description			Κŧ	3.3	:	E	1.0	High	1.0	2	:	£	ε		=	E	3.6	1.0		1.0
14	Table I		Description	steel. 60° V-notch, N=0.03 ed Tensile Strength = 190 Notched R.A. = 11.2%.	=	=	4340 Steel.	4340 Steel. 41 V-notch, R=0.01"	1340 Steel.	8	2	=	E							4340 Steel.
# # # # # # # # # # # # # # # # # # #	!		Ref.		=	=	 _		 	:	r	<u>.</u>	r	:	=	:	E	=	E	
WADD TR 60-42 44		<u> </u>		た	80	92	12	88	82	တ္ထ	33	SZ SZ	33	₹.	35	36	37	38	39	오
	WA	י מס	r 60	-42				-		4	4									

		Best Trestment	1525°F 1-1/2 hrs., OQ; Temper at 1150°F 1-1/2 hrs., AC.			1600°F, 0Q from 1500°F at			-		-	-	•	!		-			
SAE Steels 4340 and 4350 (Continued)		Chemical Composition	C-0.414, Mn-0.79, P-0.024, S-0.014 S1-0.029, Cr-0.77, M1-1.76, Mo-0.27			C-0.39, Mn-0.66, P-0.012, S-0.018 Cr-0.72, N1-1.72, Mo-0.35	44	c-0.35/0.45, Np-0.60/0.80, P-0.040, s-0.050, cr-0.60/0.90, N1-1.65/2.00, Np-0.20/0.30	ŧ	:	·	=	=	•	F	E	ε		
Table II.		Hard.	:	ŧ	ð.	322	ŧ		į	!	!	!	!	;	!	1	1	-	Vickers 360
	rties	R.A.	52.4	=	*	19	*	•	! !	ł	•	! !	!	:	į	i	•	*	•
	Static Properties	Elong.	15.0 hD	£	z	18.2	=	1	ł	!	i	ì	;	:	ł	ļ	ŀ	į	
	Stat	Ket Ket	146.9 0.24	£	=	142.2	ŧ	İ	!!!!	! !	1	į	•	:	1	į	į	1 1	:
		UTS Fe i	158.5		*	150.4	=	220.8	195	188	158.5	E	220.8	195	158.5	*	=	E	160 Nominal
		Item	₩	83	3 8	12	88	&	30	æ	8	33	ŧ	35	36	37	38	39	04
WADD	TR	60-	42			··			45										

	Specimen	Surface Finish	3/0			*							9/6 ∯.		*	•	# 1 1 1	:
		Size	0.26"	*		8		0.2		8		8	ø.9e.0	\$	•	0.8"	*	
	•	Speed	1700			*		8	ŧ	*			*	3	3	8	8	•
	Testing Machine	Kind of Test	Const.Ampl. Bending		•			8			•	=	Const.	•		ŧ	t	
timed)		Type	Krouse	=		*	=	E	z.	z	ŧ	£	t	•	=	¥	2	s
SAR Steels 4340 and 4350 (Continued)		Life, Cycles	107	=	8	2		2		2	*	н	z	*	n	ε	ŧ	.
Dan O	Fatigue Properties	St.	;	i	;	ł	÷	i	ł	i	;	i		1				•
18 434	We Pro	Se ka1	88	8	8	8	8	3	8	×	क्ष	12	Tors.	Tors. 53	Tors.	10rs.	Tors.	Tors. 35
R Stee	Fatig	Re 1	0	3	8	82	160	0	3	8	230	160	0	Tore.	Tors.	0	Tors. 20	Tore.
- 11		Ž,	1.0	=	=	z	*	2.6	*	ŧ	£	=	1.0	r	z	1.65	=	
Table II.		Description	teel. Grain Size, McQ-E	ŧ	:	E	#	4340 Steel. 60° V-notch, 0.03" deep, R = 0.01".	2	E	•	u u	teel. Smooth.	E	ŧ	4340 Steel. 60° V-notch, R = 0.01".	£	E
		; ;	4340 Steel. 7 to 8.					भ्ड ०७६५	I .	E	*	2	4340 Steel.	t .	ŧ	NS 0464	· · · · · · · · · · · · · · · · · · ·	
		Ref.	%	*	£	£	=		=	ε	£	:	t	:	t	*	=	E
•		Item	41	ğ	* 43	4	15	94	74	8	61	20	12	22	53	式	55	26

		Heat Treatment	Norm. from 1650°F, 00, from 1550 to 1600°F, 2 hrs. et 1000 to 1050°F, cooled to 500°F.	E	\$	E	2	•	ŧ		E	E	E	•		•	ŧ	E		
SAE Steels 4340 and 4350 (Continued)		Chemical Composition	c-0.40, Mn-0.74, P-0.015, 8-0.030, cr-0.82, M1-1.79, Mo-0.26	Ε	t	ε	*	2	£		ŧ	=	E	r	=	=	r	r		
Teble II.		Hard.	Re 36.7 to 39.0	:	ε	=	#	2	ŧ	E	=	E		i	1		1	1 9 5		
5-1	ties	R.A.	55.6	2		=	t	z	£	E	ŧ			i	1		ł	ļ		
	Static Properties	Elong.	13	=	=	•	2	=	£	£	E	E	<u> </u>	ł	:	:	:	:		
	Stati	YP kei	158.1 to 159.3	r	E	E	.	=	r	r	=	•	Torsion Torsion 142.5 108	E	£	=	z	E		
		UTS ks1	9°7/1	=	8	8	±	2		£	*	*	Torston 142.5	*	E	=	*	E	 	
		Item	रक्	2	£43	#	45	91	74	84	64	R	13	22	53	ま	55	56		
WADD	TR		2							47									 	

Table II. SAE Steels 4340 and 4350 (Continued)	Fatigue Properties	Description Kt Sm Se St. Life, Type Ki ksi bev. Cycles	melt, electric 1.0 No 69 h.4 107 R.R. Ro	h340 Steel. Air melt, electric 2.6 " 32 1.6 " " furnace. 60 V-notch,R=0.010".	Air melt, electric 1.0 " 85 6.7 " "	4340 Steel. Air melt, electric 2.6 " 41 2.0 " " furnace. 60° V-notch, R=0.010".	Air melt, electric 1.0 " 96 8.5 " "	4340 Steel. Air melt, electric 2.6 " 50 6.6 " " furnace. 60° V-notch, R-0.010".	Air melt, electric 1.0 No 90 5.8 107 R.R. Rooth	h340 Steel. Air melt, electric 2.6 " 47 1.9 " " " Innace. 60° V-notch, R=0.010".	Vacuum melted 1.0 " 100 5.5 " "	k340 Steel. Vacuum melted 2.6 " 40 2.8 " " steel. 60 V-notch,R=0.010".	4340 Steel. Consumable Elec- 1.0 " 124 to 5.4± Prot trode Steel, Prot Tested.	4340 Steel. Air melt, electric 1.0 No 67 4.2 107 R.R. Rore B from 3 inch rounds, forged flat.	" " 84 4.5 " " Transverse
ii		K¢				_v									£
- 1	Patie												=		
1s 4340 s	ue Propez													67 h. Transver	84 4. Transver
und 4350 (Com	ties														
(penuta	19I	Type	R.R. Moore	*	2	2	=	8	R.R. Moore	ŧ	*	£	Ł	R.R. Moore	ž
	Testing Machine	Kind of Test	Rotating Bending	*		E		E	Rotating Bending		E	E	. F	Rotating Bending	•
:		Speed	30,000	2	*	*	=	E	π,000	2	12,000	t	10,000 to 12,000	11,000	2
	es S	Sise	0.230"		2	t	8	ŧ	√.230'₽	8	.		:	0.230"	:
	Specimen	Surface Finish	2-5 aderoin.		•		•		2-5 nteroin.				.	2-5 microin.	

(Pe		Heat Trestment	Horm. 1600°P, 4 hrs., AC; Hard. 1585°P, 2 hrs., OQ; Temp. 1150°P, 4 hrs., AC. Stress Relieve 1100°P, 2 hrs.	à.	Horm. 1600°P, AC; Bard. 1525°F, 2 hrs., OQ; Temp. 875°P, 4 hrs., AC. Stress Helleve 700°P, 2 hrs.	•	HOLE. 1600'F & hrs., AC; Hard. 1875'F & hrs., OQ; Temp. 450'F 8 hrs., AC; Stab. 250'F, 28 hrs., AC; Stress Hal. 400'F, 8 hrs.	•	Horn. 1600°F 2 hrs.,AC; Ansten. 1925°F 1.5 hrs.,OQ; Temp. 650°F & hrs.,AC; Stress Relieve 550°F, & hrs.	•	Horm. 1600°F, 4 hrs., AC; Amerem. 1525°F 2 hrs., OQ; Temp. 875°F, 4 hrs., AC; Stress Relieve 700°F, 2 hrs.		Horn. 1600 F; 1 hr., AG; Austen. 1475 F; 1 hr., OQ; Temp. 350 F; 2 hrs., AG; Steh. 250 F; 24 hrs., AG; Stress Hel. 300 F; 2 hrs.	HOUR. 1690'F, & hrs., AC; Hard. 1985'F, 2 hrs., OQ; Temp. 1150'F, & hrs., AC. Stress Helieve 1100'F, 2 hrs.	Horm. 1600'F,AC; Hard. 1525'F, 2 hrs., OQ; Tump. 875'F, 4 hrs., AC. Stress Helieve 700'F, 2 hrs.
I. SAE Steels 4340 and 4350 (Continued)		Chemical Composition	C-0.395, 181-0.76, P-0.008, 8-0.016, 81-0.31, 181-1.78, Cr-0.84, 160-0.23	t	•		•	ε	=		C-0.41, Mp-0.69, P, B, 81-0.33, H1-1.77, Cr-0.89, No-0.22	•	C-0.42, 16-0.67, P-0.014, B-0.023 81-0.32, 111-1.88, Cr-0.79, 16-0.29	c-0.395, 142-0.76, P-0.008, 8-0.006, 81-0.31, 111-1.78, 02-0.84, 160-0.23	
Table II.		Eard.	же 30.4	8	Re \$1.3		51.6	8	18.1		38.6	*	₹	i	
	sets	R.A.	8	*	8	•	8		2	=	×	•	%	14	35
	Static Properties	Flore.	ส		ង		ជ		21	=	13.8		* :	17.8	9.11.9
	Static	R II	131	=	461	*	82	=	ౙ		2/1		ลี	128 17.8 fransverse	182 1 Transverse
		UES Nat	**		84	*	88		82	•	84		8	138	130
		Item	57	农	8	8	હ	જી	છ	•	ક	8	64	88	8
WA	י סס	TR 60)-42					1	19						

	8	2-5 ateroia.	_	¥			_	ģ.	_	_		_			_	
	Specimen Surface Pinish	1	•	Lapped	*	t	E	4 micr		£	*	=	1	=	E	E
	Sise	0.230"	8	0.220"		t	E	0.223"\$ 4 micro-	t	£	E	£	.	z	£	£
	Speed	m,000	2	10,000	\$	=	=	8,000	5	*	=	=	t	8	#	ε
	Testing Machine Kind of Test	Rotating Bending		Rotating Bending	2	r	E	Roteting Cant.	F	t	t	=	E	E	ŧ	E
:Imed)	e e e	R.R. Moore	ŧ	R.R. Moore	*	F	5	Krouse	\$	t	E	ŧ	5		*	E.
SAE Steels 4340 and 4350 (Continued)	Life, Cycles	107	*	107	8	=	E	Prot	ε	E	8	*	t	=	t	н
4 pas	orties 8t.	84 7.6 Transverse	86 7.7 Transverse	;	;	ļ	1	5.9	8.4	7.0	8.8	5.5	5.3	4.2	6.8	7.3
०५६५ ह	Prope	190 H	96 Trans	75.5	35.0	8.5	45.9	97.0	₹. ₹	88.1	6.48	86.0	87.3	84.5	81.6	88.8
E Steel	Patigue Properties Sm Se St. kei kei per	8		-	=	±	•	§	2	z.	=	£	=	£	£	ε
[]	3	1.0		1.0	8.	1.0	8.5	1.0	t	=	.	r	2	ŧ	;	=
Table II.	Description	4340 Steel. Air melt, electric furnace; transverse specimens from 3 inch rounds, forged flat.	•	Smooth	60° V-notch, R = 0.015"	Smooth	60° V-notch, R = 0.015"	. Longitudinal	Transverse. Same heat as Item 76.	Longitudinal	Transverse. Same heat as Item 78.	Longitudinal	Transverse. Same heat as Item 80.	Longitudinal	Transverse. Same heat as Item 82.	Longitudinal
		4340 Steel. furnace; to from 3 inch		Hot-Rolled 4340 Steel.	E	*	r	4340 Steel.	E	£	E	=	£	ŧ	=	ŧ
	Ref.	30	ŧ	2	E	ŧ	2	14	:	=	ŧ	£	2	:	:	=
	Item	5	건	ध	23	47	22	76	11	82	79	8	81	8	83	ਡੇ
IAW	DD TR	60-42		···			5	0		·	· · · · · · · · · · · · · · · · · · ·					

	Best Trestment	Horm. 1600'F, 2 hrs.,Ady Ametem. 1985'F, 1.5 hrs.,Ody Temp. 650'F, 4 hrs., Ady Stress Helieve 550'F, 4 hrs.	Horm. 1600°F, & hrs., AC; Herd. 1875°F, & hrs., OQ; Temp. 450°F,8 hrs., AC; Stab. 250°F,2% hrs., AC; Stress Bel. AOO°F, & hrs.	Mormalized 1650'F, Tempered 1800'F.	:	Quenched 1500°F, Tempered 1085°F.	•	Selt bath 1550°F 15 min., 00; Temper 30 min. to Re tite on 13/32" \$	5	=	•	1550°F, controlled etmos., 1 hr., 0Q; Temper 850°F, neutral salt, 40 mis.	2	1550°F, neutral salt, 15 min., 0Q; Temper 850°F, neutral salt, 30 min.	•	1550°F, neutral salt, 15 min., 0Q, Temper 850°F, neutral salt, 20 min.
	Chemical Composition	C-0.395, Ne-0.76, P-0.008, S-0.016, S1-0.31, N1-1.78, Cr-0.84, No-0.23		c-0.39, Ma-0.76, 81-0.30, P-0.035, 8-0.013, Gr-0.78, M1-1.79, No-0.25	ŧ	•		C-0.40, ME-0.68, P-0.015, B-0.018, 81-0.26, N1-1.74, Cr-0.79, No-0.24		C-0.44, Ma-0.74, P-0.012, B-0.015, S1-0.25, H1-1.73, Cr-0.74, No-0.25	•	C-0.40, Mn-0.80, P-0.011, S-0.010, S1-0.30, H1-1.77, Cr-0.74, No-0.27	ŧ	C-0.39, ML-0.81, P-0.012, B-0.019, 81-0.26, N1-1.79, Cr-0.84, No-0.28		C-0.40, M-0.80, P-0.012, 8-0.018, 81-0.30, H1-1.80, C-0.87, No-0.27
	Hard.	i	i	H SS	*	375	8	Re 140 Long.	to to Trene.	ig to	St.	9 F	of France.	5 <u>2</u>	39 Trebe.	3 5
100	R.A.	8	ಸ	63.8	*	56.3		5 <u>1</u> 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	37 Trans.	ige.	37 Trans.	# 1	k7 Trans.	86 ja	38 Trans.	ion.
Static Properties	Flong.	9.3	9.0	23.5	=	17.0		11.13 1003	9.8 Trens.	10.7 Long.	10.0 Frans.	1.13 183	12.3 Trens.	11.2 Long.	11.5 Frans.	Long.
Static	er ig	211 Irangver	227 Transverse	98.9		158.1	*	85 3	191 Frens.	25. 20.	218	84 <u>6</u>	188 Trans.	189 168 168 168	186 Frans.	87 5
	Est of	536	270	9.421	=	168.4	*	201 100 (5)	201 Trans.	2 23 1 28 1 28	frans.	198 198	198 Frans.	2007 2007	200 Frens.	201 Long.
	Item	2	r L	22	ಬ	*	2	22	#	و و	62	8	ಕ	8	83	ಹೆ

. SAE Steels 4340 and 4350 (Continued)		Chemical Composition Heat Trestment	C-0.40, Ma-0.80, P-0.012, B-0.018, 1550°F, neutral salt, 15 min., OQ. 81-0.30, H1-1.80, Cr-0.87, Mo-0.27 Temper, 850°F, neutral salt, 20 min.	6-0.50, Ma-0.73, P-0.014, 8-0.013, 1600°F, 4 hrs., AC; 1500°,2 hrs., OQ; 81-0.30, H1-1.84, Gr-0.76, Mo-0.24 Temper 450°F,6 hrs., AC; 450°F,6 hrs.,	Acj Stabilize 270 F,27 are, Acj Stabilize 270 F,27 are, Acj Stabilize 400"F, & hrs., FC.	C-0.54, Mn-0.78, P-0.017, S-0.014, Salt bath 1550"F, 15 min., 00; Tampered 30 min. to RC hizz on 13/32" \$		0-0.52, Mn-0.74, P-0.016, B-0.012, 81-0.32, H1-1.79, Gr-0.81, Mo-0.27, Cn-0.18	•	C-0.48, Mn-0.67, P-0.011, B-0.013, Salt bath 1550°F 15 min., OQ; 81-0.29, H1-1.72, Cr-0.75, No-0.23, Tempered 900°F, 30 min.		C-0.49, Mn-0.76, P-0.015, S-0.014, Salt bath 1550°F, 15 min., OQ, 14-0.29, H1-1.79, Cr-0.80, No-0.23, Tempered, 900°F, 30 min.	•
Tehle II.		Hard.	41 Trens.	28	8	15 and	trans.	Long.	k3 Trans.	kı Long.	he Trens.	te Long.	St. Trade
	ties	R.A.	16 Trens.	32.3		15 39	35 frans.	\$ 5	t. Trans.	15 36 15 84	37 Trans.	46 Long.	49 Trans.
	Static Properties	Rlong.	10.3 Trans.	9.5		11.2	9.5 Trans.	10.0 Long.	9.3 Frens.	11.7 Long.	10.7 Trans.	10.0 Long.	8.0 Trans.
	Stat1(E TS	197 Trens.	248.4	•	25 13 15 13 15 13	206 Trans.	पूर्व हुन्छ <u>ा</u>	211 Trans.	198 198	196 10.7 Trans. Trans.	20th Long.	Prent.
		UES Ket	203 Trans.	300.6		215	नेत्र इस्तार्थ	218 Long.	Property	208 1086	207 Trans.	214 Long.	214 Trans.
		Item	ક્ષ	8	24	88	&	8.	<u>ਡ</u>	81	क्ष	ま	88

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!	tnem	Surface Finish	35 micro inch	. sa	r.	1	5 micro inch	5 "	. 8	. ot	35-40 "	. or			• 54	8	r •
	Specimen	Size	0.230%						0.12" x 1.25"				0.230"		•	=	•
!	8	Speed	10,000	*	R		*	2	1,600	*	8		10,000	*	ŧ	E	
	Testing Machine	Kind of Test	Bot. Bending					*	Bending			•	Rot. Bending	2		E	•
048	盂	Type	R.R. Moore Cant.			r		*	Vib. Cant.			a.	R.R. Moore Cant.	¥	x	*	:
SAE Steels 52100 to 98840		Life, Cycles	101		*	*	2	*	=	8	ŧ	#	8	8	*	2	£
els 52	pertie	9¢.	1	:	•	:	į	1	1	i	1	•	1	ł	ł	ł	1
AE Ste	Fatigue Properties	8 4 1	147	041	137	136	83	121	જ	29	45	74	22	०क्ष	28	705	ま
п. в	Pati	Est S	£	=			=	•			=	=	=		E	•	•
Table III.		3	1.0	8	E	8	.	*	*		=		=	*	*		.
		Description	"Essentially type 52100 Steel with Added Vanadium"	*	=	\$	•		*	8	F	I	•	2	ŧ	*	2
		Ref.	82		:	*	*	2		ŧ		*	8	*	*	*	ŧ
		Ite	-	Q	m	*	ĸ	9	7	8	8	ន	я	થ	ន	#	ង
WADI) T	R 60-	-42						54	ļ							

		Heat Treatment	og fræm 1550°F; Temp. 400°F, 1 hr.	•	8	8	.	•	•		•	*	04 from 1550°F; Temp. 850°F, 1 hr.	•	•	2	2		
Table III. SAE Steels 52100 to 983ho (Continued)		Chemical Composition	C-1.00, Cr-1.40, Ma-0.20, V-0.20, 81-0.25		2		Ε		E		ŧ	•	=	E		E	2		
Teble II		Hard.	Re 59		*	*		8	*	*	*	E	54		8	8	*		
	100	R.A.	•	į	į	i	i	į	:	i	i	į	1	i	ŀ	i	į		
	Static Properties	Elong.	i	į	ł	i	i	į	•	į	į	:	•	i	i	ŧ	ļ		
	9tet1	e i	ł	1	į	i	į	:	ŀ	ł	ł	į		į	į	ŧ	į		
		UTB 124	i	ļ	•	:	ł	1	i	i	;	•	1	•	ł	į	ł		
		Item	τ	a	m	*	2	9	7	0	•	ឧ	я	2	ឌ	춁	સ		

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	Specimen	Surface Finish	170 miero- inch	. 87	. 8.	ঃ	91		35-40 "	8	. 8	. 8	. 03	3 *			
	Å.	Sise	0.230"\$	0.12" x 1.25"		ŧ				Flat 0.050° Thick			*		1	i	
	\$	Speed offer	10,000	1,600			•	*	#					13,000	*	*	•
ุก	Testing Machine	Kind of Test	Rot. Bending	Bending					=	*	•	*	=	Bending		2	•
Table III. SAE Steels 52100 to 98840 (Continued)		ert.	R.R. Moore Cant.	Vib. Caut.	:	*	:	8	*	8		8		Rot. Cant.	:	E	t .
co Seeko		Life, Cycles	101		*		*	2	*	8		=		*	*	8	*
52.100	rties	, i	•	i	ļ	i	ł	ł	•	1	!	1	1	ł	i	į	i
teels	Prope	8	8	83	æ	ದ	8	8	\$	8	85‡	754	\$	130#	140	135±	1404
SAE 8	Fatigue Properties	Se Si	2			=			=	2	*		=	E	=	*	E
e III.		χ.	1.0	*	*			r	E	2						2	2
Tebi		Description	"Essentially type 52100 Steel with Added Venedium".		*	£	*	8	•	Regular 52100 Steel.		*	*	Regular 52100 Steel.	*	8	8
		Ref.	32	ŧ	*		*	*		*	8	*		33	ŧ		#
		Item	97	17	87	95	8	ส	8	ୟ	ಸೆ	8	%	12	88	&	8
WADD	Tа	60-	42							6							

!		Heat Trestment	0q from 1550°F; Tomp. 850°F, 1 hr.	.	*	*	*	*	E	00 from 1537 F; Tomp. 347 F; 1 hr.	*	2	*	0Q; Tomp. 347°F, 45 min.	Q 338°F, Selt, 3 min.; Temp. 347°F, 45 min.	q 426 F, Salt, 90 min.; Temp. 347 F, 45 min.	q 428°F, 90 min.; Temp. 464°F, 4 hrs.	
Table III. SAE Steels \$2100 to 98B40 (Continued)		Chemical Composition	C-1.00, Cr-1.40, Mr-0.20, V-0.20, S1-0.25	z	t	•		E	:	4 = = = = = = = = = = = = = = = = = = =	1	=						
Table III		Hard.	Rc 45	8	E	*		*		63.4	62.1	63.0	62.2	63.5	63.9	61.8	61.7	
	ites	R.A.	•	į	į	į	i	i	į	i	ŧ	į	•	i	1	į	•	
	Static Properties	Flong.	;	ł	i	į	į	į	;	i	i	i	-	ļ	!	•	i	
	8tet1	e i	ţ	;	ł	į	į	:	1	ŀ	ŧ	į	•	1	ŀ	i	ļ	
		USES Pet	i	!	i	ł	ł	į	•	ı	ł	ł	•	į	į	1	į	
		Item	97	17	କ୍ଷ	61	8	ส	ผ	ีย	#2	83	8	21	88	&	8	

					1	Bot fant Demont for	1		The fact of the fa	Peating Machine	2	8	Specimen.
# 21	Ref.	Description	rtion	¥	6	8 H	i di	Liffe, Cycles	Type	Kind of Test	Speed	8120	Surface Finish
æ	33	Regular 52100 Steel.	19 1.	1.0	2	춁	1	101	Rot. Cent.	Bending	13,000	•	3 micro
ĸ	×					130#		*	*		2		3.
EX.	2	Cast 8630 Steel.	Smooth	1.0		0:4	1	2		8	8	į	:
ま	*	2	60° V-notch R = 0.015"	а а		33.1	į	*		*	*		s
35	*	8	Smooth	1.0		6.49	į		*	=			.
36	8	E	60° V-notch R = 0.015"	8.8	*	38.6	•	2	*	.			=
37		Hot Rolled 8640 Steel.	Smooth	7.0	2	64.5	:		E	•	*	•	E :
8		•	60° V-notch R = 0.015"	8	*	38.0	į	8	=	•	*		: :
39	ŧ		Smooth	1.0	s	77.8	;	*	*	•	s		*
Ş	*	•	60° V-potch R = 0.015"	2.2	£	37.₺							
#	80	AIBI 1ÀB50 Steel.	Smooth	1.0		IJ	i	*			7,200	0.25"	2/0 Bany
3	8	Remit-c	Semi-circ. notch R = 0.050"	Yes	*	39					8	0.25.6	•
£3	ສ	98Bko Steel	Smooth	1.0	욡	113#	i	701		Rot. Bend.		0.186"\$	Mech. Politeh
\$	8	•	60° Y-notch 0.038" deep R = 0.0907"	8.0	•	\$	1	8	; ; ;	*			

		Reat Treatment	q 518°F, Selt, 1 hr.; Temp. 347°F, 45 min.	09, 30 sec.; Temp. 572°F, 45 min.	Hormalised 1650°F, Tempered 1200°F.	2	Quenched 1550'r, Tempered 1200'r.	2	Hormalized 1650°F, Tempered 1200°F.		Quenched 1525°F, Tempered 1200°F.	2	1550°F, 10 min., 0Q; Temper 550°F.	8	1550°F, 0Q; Tempered &00°F.	2
. SAE Steels 52100 to 98840 (Continued)		Chemical Composition			C-0.29, ND-0.73, S1-0.45, P-0.026, 8-0.035, Cr-0.52, N1-0.57, NO-0.23	2	ž	2	C-0.42, Mn-0.89, 81-0.30, P-0.040, 8-0.014, Cr-0.57, H1-0.61, Mo-0.22		2	2	C-0.52, M-0.84, P-0.011, S-0.030, S1-0.27, B-0.0005	•	C-0.46, Ma-0.79, P-0.017, B-0.017, B1-0.35, M1-0.86, Cr-0.81, M0-0.19, B-1	E
Table III.		Eard.	Rc 58.5	59.4	823	*	386		217		586	*	Re 51	8	-	i
	ties	R.A.	ł	ł	53.7	t	34.5	*	60.2		65.6	*	45.8	=	33*	E
	Static Properties	Flong.	•	i	19.0	t	14.8	=	24.0	2	21.5	=	9.85	2	8.5	
	Stat1	TP Fest	•	•	95.6	*	125.8	•	88.5		124.2	=	242.0	*	2354	
		UTB Ket	•••	•	270.5	*	137.5	2	108.5	8	138.2	E	5°TL2	*	302.6	•
		Item	æ	e R	æ	煮	83	36	37	82	39	3	T ų	्रभ	£43	\$

WADD TR 60-42

	Specimen	81se Surface Finish	0.188"s Mech. Polish		" Mech. Polish		. Mech. Polish		" Mech. Polish	•
	8	Speed cym	•				1			
	Testing Machine	Kind of Test	Rotating Bending		*		•	•	•	•
rtimed)	F	Type	****		!		!		1	
SAE Steels 52100 to 989k0 (Continued)		Liffe, Cycles	101	8		*	3	*	E .	8
\$2100 ¢	Patigue Properties	at.	•	ł	l	•	į	1	į	1
teels	TY SE	8 12 12	102	ğ	켮	ğ	834	\$	8	&
848	Pati	San Red	2			•		*		
ij		3	1.0	0 .	1.0	8.0	1.0	8.0	1.0	8
Pable III.		Description	Smooth	60° V-notch 0.038" deep R = 0.0007"	Smooth	60° V-notch 0.038" deep R = 0.0007"	Bacoth	60° V-notch 0.038" deep R = 0.0007"	Smooth	60° Y-notch 0.038" deep R = 0.0007"
		Desk	988to steel.			•	2	t	2	2
		Ref.	13	*	*		*	8		
		Item	Sŧ	2	24	9	<u>\$</u>	ዩ	ц	25
WADD	TR (50-42	2				60			

		East Treatment	1550'F, OQ Tempered 500'F.		15507, 00; Impored 5757.	•	15507, 00; Impared 6907.	•	1550'F, 04, Tempered 860'F.		
. SAE Steels 52100 to 988h0 (Continued)		Chemical Composition	C-0.46, Ma-0.79, P-0.017, S-0.017, S1-0.35, N1-0.86, Cx-0.81, M0-0.19, B-1	•	•	ŧ	•	•	•	8	
Table III.		Bard.	ŧ	1	ł	į	:	ł	!	į	
	ties	R.A.	33#	*	芸		푰		35±		
	Static Properties	Flong.	X	*	Ħ,	=	8.54		ğ		
į	Stati	re ket	2454	*	235±	=	225		1991	•	
		UTS kai	102	*	270	*	245		Ŕ	*	
		Item	54	73	14	92	64	ደ	น	R	

									7			,		
	Specimen	Surface	Mech. Polish	1		:	*	*	2-5 micro- inch		2	Mech. Polish	t	ŧ
	Spec	Size	0.200"	r		:			0.230"	2	ŧ	0.200%		E
	e e	Speed	1800	8	ŧ	*	\$	ŧ	11,000	*	*	1800	*	\$
	Testing Machine	Kind of Test	Push- Pull	t	£		5		Rotating Bending	E	8	Push- Pull	=	
	Tes	Type	Sonntag	*	E	E	E	\$	R.R. Moore		=	Bonntag	z	•
136		Life, Cycles	106	E	\$	E	\$	\$	Prot	8	3	106	5	£
Special Steels	Fatigue Properties	St. Dev.		ŀ	ł	:	ļ	ł	5.64	4.14	6.1±	i	į	ļ
Speci	gue Pro	Kai	135±	85±	1204	8	120	85±	-311 711	911 811	87 82 82 83	\$	85±	130#
Table IV.	Pati	S _{IR} Ke 1	£		E	t	*	=	 =		•	E.		Ε
Tabl		쟢	1.0	5	=	ŧ	ŧ	*	s	t	t	.	=	s
		tion	Longitudinal Specimens	Transverse Specimens	Longitudinel Specimens	Transverse Specimens	Longitudinal Specimens	Transverse Specimens	Longitudinal Specimens (Prot Tested)	:	2	Longitudinal Specimens	Transverse Specimens	Longitudinal Specimens
		Description	"Tricent" Steel. Longitudinal (Electric Furnace) Specimens	r	•	s		t	E	"Tricent" Steel. (Consumable Electrode)	"Super Hy-Tuf" (Consumable Electrode)	Cruc. UHB-260 Steel (Electric Furnace)	r	Super TM-2 Steel. Longitudinal (Electric Furnace) Specimens
	-	Ref.	₹	:	•	=	.	E	&	t	t	₹.	.	t .
		Item	1	œ	m		~	9	7	ω	o,	OI.	я	ង
WADD	TR	60-1	12					62						

		Heat Trestment	1600*F, OQ; Temper 400*F, 4 hrs.; AC (No stress relief mentioned)	ŧ	1600°F, OQ; Temper 550°F, 4 hrs.,	£	1600°F, OQ; Temper 700°F, & hrs., Ac.	F	Normalize 1700°F, 1 hr., AC; Harden 1650°F, 1 hr., OQ; Temper 400°F, 2 hrs. AC; Stabilize 250°F, 24 hrs., AC; Stress Relieve 300°F, 2 hrs., AC.	Hormalize 1700°F, 1 hr., AC; Harden 1650°F, 1 hr., OQ; Temper 475°F, 2 hrs. AC; Stabilize 250°F, 24 hrs., AC; Stress Relieve 300°F, 2 hrs., AC.	Mormalize 1700°F, 1 hr., AC; Harden 1700°F, 1 hr., OQ; Temper 700°F, 2 hrs. AC; Stabilize 250°F, 24 hrs., AC; Stress Relieve 300°F, 2 hrs., AC.	1700'F, 0Q; Temper 550'F, 4 hrs. AC.	£	1600°F, OQ; Temper 500°F, & hrs., AG.
Table VI. Special Steels (Continued)		Chemical Composition	C-0.39, Mn-0.74, P-0.014, S-0.014, S1-1.54, H1-1.83, Cr-0.83, Mo-0.38, V-0.07	z	Ε	ε	ŧ	ε	c-0.40, m-0.71, P-0.012, s-0.006, s1-1.64, H1-1.81, ct-0.87, mo-0.38, V-0.08	C-0.43, Mn-0.76, P-0.012, S-0.022, S1-1.62, H1-1.75, Cr-0.79, Mo-0.45, V-0.07	C-0.44, Mn-1.29, P-0.011, B-0.021, B1-2.23, E1, Cr-1.46, Mo-0.38, V-0.19	C-0.35, Ma-1.20, P-0.023, 8-0.017, H1, Cr-1.26, Mo-0.32, V-0.20	r	C-0.41, Mn-0.72, F-0.012, B-0.014, B1-0.61, R1-2.08, Cr-1.15, Mo-0.44, V, Ch-0.14
		Hard.	i	-	;	!	i	i	54.2	54.5	\$;	;	;
	ties	R.A.	:	ł	}	i	i	į	37	28 5.	%	i	ł	ł
	Static Properties	Elong.		i	į	ŀ	i	į	ជ	01	8.2	i	ł	1
	Stati	Ks 12		i	ł	ł	ł	!	883	251	267.3	i	i	•
		VIIS ks1	295‡	E	580 t	ŧ	275±	=	₹ 8	304.6	313.2	295±		270±
		Item	1	Q	٣	4	2	9	7	Φ	6	10	п	टा
WADD	TR	60-1	1 2						63					

	Specimen	Surface Finish	Mach. Polish	Mech. Polish	: :	Mach. Polish	‡ • •	
	di S	Size	0.200"¢	0.188"∮	t		E	
	ine	Speed cpm	1800			•		
	Testing Machine	Kind of Test	Push- Pull	Roteting Bending	t	*	8	
		Type	Sonntag	-		1	1	
Special Steels (Continued)	2	Life, Cycles	106	101	•	=	t	
9618 (perti	St. Dev.	1	i	ļ	i	i	
is1 8t	Fatigue Properties	Se ksi	85	8	ž.	8	ğ	
Spec	Fatig	S _m ks1	<u>8</u>	옾	r	ě	E	
Table IV.		Kt	0.1	1.0	8.0	1.0	8.0	
Tab		ion	Fransverse Specimens	Smooth	60° V-notch, 0.038" deep R = 0.0007"	Smooth	60° V-notch, 0.038" deep R = 0.0007"	
		Description	Super IM-2 Steel. Transverse (Electric Furnace) Specimens	Hy-fuf (Electric furnace)		Super Hy-fuf	E	
		Ref.	ਲੈ	ಚ	2	t	2	
		Item	ដ	큐	સ	76	17	
WADD	TR	60-1	12				6	54

		Heat Trestment	1600°F, OQ; Temper 500°F, & hrs., AC.	1575°F, 0Q; Temper 500°F.	ŧ	1700°F, 0Q; Temper 800°F.		
Special Steels (Continued)		Chemical Composition	C-0.41, Ma-0.72, P-0.012, S-0.014, S1-0.61,	c-0.285, M-1.29, P-0.019, 8-0.015, 81-1.58, 11-1.87, cr-0.24, Mo-0.40	ŧ	C-0.41, Mr-1.28, P-0.014, S-0.024, S1-1.77, Cr-1.26, Mo-0.33, V-0.17	*	
Table IV.		Hard	i	1	ł	ł	i	
~**	ties	R.A.	ì	:	ļ	33‡	*	
	Static Properties	Elong.		•	į	8.5±	*	
	Stati	YP	i	560±	*	210#	E	
		UTB ks1	270£	243	*	98	¥	
		Item	ક્ષ	#	15	92	17	

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	Laen	Surface Finish	5 miero- inch		t	•	400 Grit	600 Grit	500 Grit	400 Grit	600 Grit			5 micro- inch		
	uest, dedg	Bise	0.230"6	.	*	•	0.250"\$	=	0.187"∮	0.250"\$	T.			0.230"\$		
	9	Speed	10,500	8	g	ŧ	3,600	:	-	3,600	2			10,500		
	Testing Machine	Kind of Test	Rotating Bending	8	8 ·	e	Axial	E	Rotating Bending	Axial	£	Axial	ı	Rotating Bending		
	Tec	Type	R.R. Moore	E	=	E	9	t t t	R.R. Moore	***	1 1 2 0			R.R. Moore		
978		Life, Cycles	Lot		E	t	2.6x107	2	107	2.6x107	#	300	#	7οι	2(107)	
Heat Resistant Alloys	perties	St. Dev.	i	•	म्य	Small	1	1	:	;	i			7‡		
Resista	Patigue Properties	Se ks1	1294	€7±	132‡	‡ 111	35±	**	140	€1 ‡	56 ‡	59	34	108#	\$7\$	
Heat	Patie	ke1	S.	E	r	T	.	=	No	E	r	59	34	No	No	:
e V.		꿏	1.0	2.6	1.0	5.6	1.0	3.4	1.0	1.0	3.4	1.0	2.5	1.0	1.0	
Table V.		lption	Smooth	60° V-notch R = 0.010"	Smooth	60° V-notch R = 0.010"	Smooth	60° V-notch R = 0.010"	Vacuum Melt Smooth	Smooth	60° V-notch R = 0.010"			Smooth	Smooth	
		Description	Ferrovac WB-49 Steel	£	Ferrovac WB-49, Nitrided		GMR-235 Alloy	r	Halmo Tool Steel	Hastelloy R-235 Alloy	•	H-11 Alloy Ber	u	H-23 Hot Work Steel	Inconel X Alloy	
		Ref.	35	2	E	E	36	=	37	36	ŧ	38	2	35	39	
·_ ·		Item	٦	a	м	≉	2	9	7	80	6	ន	п	ट्य	13	
LIAT	א מו	nD 60	110					6.0	_							

WADD TR 60-42

		Heat Trestment	1500°F, 30 min., 2225°F, 7 min., rG; 1050°F, 2 hrs., AG; 1050°F, 2 hrs., AC; After machining, 1000°F, 2 hrs.	2	1500°F, 30 min.; 2225°F, 7 min., A'; 1050°F, 2 hrs., AC; 1050°F, 2 hrs., AC; Mitride 975°F, 48 hrs.	E			Preheat 1500°F; Austen. 2100°F, OQ; Temper 1000°F, 2 hrs.; Retemper 1000°F, 2 hrs.	2150°F, 1/2 hr., AC.	z.			1400°F, 30 min.; 2250°F, 5 min., 00 to black, AC; 1100°F 1 hr., 2 hrs., 2 hrs.; After Machining, 1000°F, 2 hrs.	1550°F, 24 hrs., AC; 1300°F, 20 hrs., AC.
Heat Resistant Alloys (Continued)		Chemical Composition	C-1.03, Mn-0.42, 81-0.26, Cr-4.30, Co-5.32, Mo-3.94, W-6.84, V-1.74	=	•	22	C-0.19, Al-2.95, T1-2.25, Mo-5.50, Cr-15.7, Fe-10.0, S1-0.20, Mn-0.02, B1-0.092, Ni-bel.	=	C-0.59, Mn-0.31, P-0.005, S-0.007, S1-1.10, Cr-4.79, V-0.51, Mo-5.22	C-0.17, 8-0.017, Al-2.06, Ti-2.55, No-5.31, Cr-15.51, Co-0.27, Fe-9.95, 81-0.22, Nn-0.03, P-0.001, Ni-bal.	n			C-0.33, Mn-0.45, 81-0.52, Cr-11.49, N1-0.10, Mo-0.32, W-11.80	C-0.40, Mn-0.51, P, S-0.007, S1-0.39, N1-73.16, Cr-14.61, Cb-1.04, Fe-6.87, A1-0.88, T1-2.44, Cu-0.03
Table V.		Hard.	Вс 67	2	r	t	ì	ļ	% %	i		ļ	-:		-
E11	ties	R.A.	i	į	1	į	ŀ	i	•		1	ł		1	30
	Static Properties	Klong.		ł		i	18.5 1650 F	=		17 1650°F	£	i	ł		4 г
	Btatic	TP ks1		ł	:	ł		į	310	1	ł	i		143	8/20
		UTS ksi		ł		;	64 1650°F	£	370	70 1650 °F	s	8 86	E	185±	391
		Item	н	CI.	m	#	5	9	7	ω	6	or	ជ	ង	13
WADI) T	R 60-	42					67						<u> </u>	

	Specimen	Surface Finish		400 Grit	10 micro- inch			1	1 5 2 5 5	t ! !	!	:	1 0 1 1	1	! :	
	Spe	Size		0.250"\$	F	0.20"\$	E	.	\$	t	.	ŧ	r.	*	8	
		Speed		3,600	=	3,600	t	1	1 1 1	3,600	t	E	E	ŧ	2	
	Testing Machine	Kind of Test	Axial	Axtel	:	Axial	t	t	.	=	t	r	•	E	E	
7	Te	Type		Special	E		1	-		1	# ! !	# 	# 1 1 1	!		
Heat Resistant Alloys (Continued)		Life, Cycles	106	201.07	=	2.17x107 100 hrs.	t	100 hrs.	=	2.17x10 ⁷ 100 hrs.	t	:	.	ŧ	1	$\left. \right $
110ys	Fatigue Properties	st. Dev.	į	;	-	ļ	ļ	;	:	;	ł	i	i	į	}	
tant A	ue Pro	Se ksi	31.5	52‡	22±	25	33	None	£	9	7.5	13	15	เร	17	
Resis	Fatig	Sm ks1	31.5	S.	=	0	0	88	23	23	33	8	83	10.5	8.5	
1		Ķ	1.0	1.0	3.4	1.0	2.9	1.0	2.9	1.0	2.9	1.0	2.9	1.0	2.9	
Table V.		rtion		Smooth	60° V-notch R = 0.010"	Smooth	60° V-notch R = 0.010"	Smooth	60° V-notch R = 0.010"	Smooth	6c° V-notch R = 0.010"	Smooth	60° V-notch R = 0.010"	Smooth	60° V-notch R = 0.010"	
		Description	Incomel X Sheet	Incomel X-550 Alloy	t	Incomel 713C. Tests at 1700°F.	E .	ŧ	:	t	•	z.	t	*		
i.		Ref.	38	Oţ	e e	147	ŧ	*		ŧ	*	ŧ	£	2	*	٦
		Item	77.	15	16	7.7	18	61	ଷ	ส	8	છ	₹	25	98	
WADD	TR	60-4	2						68							

		Heat Treatment		2150°F, 1 hr., AC; 1600°F, 4 hrs., AC; 1350°F, 4 hrs., AC.	E	None. Used in "as cast" condition.		ŧ	=	:	Ε	:	E	:		
Heat Resistant Alloys (Continued)		Chemical Composition		C-0.05, Mm-0.73, 81-0.28, 8-0.007, Cr-14.92 T1-2.5, Al-1.16, Fe-6.59, Cu-1.03, Cb + Te-1.03, N1-bel.		Cr-11.9, Fe-0.86, S1-0.49, Mn-0.13, C-0.11, Mo-5.0, Al-5.6, T1-0.52, Cb-2.1, N1-bal.	=	=	=	=	=	F	=	ŧ	ı	
Table V.		Hard.		38 38	ŧ		:	i	i	!	1	ļ	i	1 1	= 1 =	
61	ties	R.A.	•	0 3 1	6 6 1	ł	1	į	ł	i	ł	i	;	ļ	1	
	Static Properties	Elong.		7	=	1	ŀ	1	i	ł	i	!	ł	•		
4	Static	YP ks1	:	115.0 0.2%	I	1	!	i	ļ	i	į	1	1	1	:	
		UTS ksi	175	173.5	=	80 1700°F	=	=	E	:	•	=	=	E	=	
		Item	14	15	91	17	3,8	19	8	ส	83	23	₩2	52	56	

									<u> </u>						
	Specimen Surface Finish		500 Grit		5 micro- inch	£	*	T	Polish		:	:			
	Spec Size	0.250"\$	0.187"ø		0.230"\$	į	t	#	0.2"	0.206"		:			
	ne Speed cpm			8 8 9 8	10,500	E	ŧ	=	1,000	£		t t		*****	
	Testing Machine Kind of Test	Rotating Cant.	Rotating Bending	E	Rotating Bending	£	r	t	Rotating Cantil.	£	Axial	T	F	E	
ন	Type		R.R. Moore	E	R.R. Moore	E	E	E	# 1 1 1	!	:	3 1	1 1 1 1	9	
Heat Resistant Alloys (Continued)	s Life, Cycles	2×107	107	F	Tot	5	=	н	2(107)	=	106	=	2	#	
110ys	Fatigue Properties Sm Se St. ksi ksi Dev.		i	i	13	٧	#		! ! !	j	i	Ì	ł	1	
stent A	gue Pro Se kei	72	130	125	921	7	126±	136±	53	ર્ત્ય	143	22.5	143	7,1	
t Resi	Fati Sm ksi	No	Mo	t	ē.	:	=	=	S.	£	143	22.5	143	71	
Hes	Kt	1.0	1.0	t	1.0	5.6	1.0	2.6	1.0	2.6	1.0	2.5	1.0	2.5	
Table V.	Description	Smooth	Vacuum Melt Smooth	*	Smooth	60° V-notch R = 0.010"	1. Smooth	60° V-noteh R = 0.010"	Smooth	60° V-notch R - 0.010"	PH-15-7 Mo Sheet Stainless Steel, Condition RH 950		t Stainless tion TH 1050		
	Pe	Lepalloy Alloy	M-1 Tool Steel	MV-1 Tool Steel	M-10 Steel.	r	M-10 Nitrided.	t	M-155 Alloy.	£	PH-15-7 Mo Sheet Stainle Steel, Condition RH 950	11	17-7 PH Sheet Stainless Steel, Condition TH 1050	н	
	Ref.	टम्	37	t	35	ε	=	ε	£t _t	F	38	¥	H	z	
	Item	12	58	&	30	31	32	33	7€	35	36	37	38	39	
DDAW	TR 60-1	12					7	0							

		Heat Treatment	Forged at 2020'F-2050'F and 17001800'F; Stress Relieved 1275'F, 6 hrs.,AG; 200'F 45 min.,500'F 30 min.,1320'F 4 hrs.,AG.	Preheat 1500°F; Austen. 2100°F, OQ; Temper 1000°F, 2 hrs.; Retemper 1000°F, 2 hrs.	±	1450°F,30 min.; 2150°F,5 min.; Og to black AC; 1100°F,2 hrs.,AC; 1100°F,2 hrs.,AC; After Machining,1000°F in protective stmosphere.	£	Same as above, except not stress relieved, at 1000 F, but nitrided 975 F, 48 hrs.	Ē	1400°F, 16 hrs., AC.	E	Refrigerated, and Hardened at 950°F.	E	Treated, and Hardened at 1050°F.		
Heat Resistant Alloys (Continued)		Chemical Composition	C-0.30, Cr-12.20, Mn-1.05, N1-0.22, S1-0.35, Mo-2.87, P-0.019, S-0.024, V-0.28, Fe-bal.	C-0.80, Mn-0.25, P-0.004, s-0.007, S1-0.32, Cr-3.76, V-1.15, W-1.53, Mo-8.54, Cu-0.01, N1-0.07	C-0.81, Mn-0.26, P-0.004, S-0.007, S1-0.14, Cr-3.97, V-1.07, W-0.01, Mo-4.29, Cu-0.01, N1-0.05	C-0.86, Mn-0.25, S1-0.28, Cr-3.99, V-2.04, Mo-7.98, P-0.015, S-0.006	ŧ	C-0.86, Mn-0.25, S1-0.28, Cr-3.99 V-2.04, Mo-7.98, P-0.015, S-0.006	=	C-0.15, Mn-1.74, S1-0.37, N1-19.4, Cr-21.7, Mo-2.76, W-1.90, Co-19.0, Cb-0.76, Fe-32.1, N-0.14	F	Cr-15, N1-7, Mo-2 (Nominal)	Ξ	Gr-17, Ni-7 (Nominal)	£	
Table V.		Hard.	Rc 27-30	% 88	ı	Rc 61-62		;	i	İ	i		!			
HI	ties	R.A.	68.8	 		!	į	;	;	1	;	;	1	1 1	-	
	Static Properties	Elong.	21.	ł	-	1	:	1	;	まし	E	1	;	:	1	
	Stati	YP kei	0.2%	310	295	1	ļ	! !		60.5 0.25	ŧ		1	i	:	
		UTS	129	370	370	1	į	1	•	119	=	225	E	180	*	
		Item	22	28	29	30	33	32	33	₹.	35	36	37	38	39	
WADI	D T I	r 60-	42			•	71									

	Specimen	Surface Finish	Under 10 Microin.	Ground Notch	< 10 Microin.	Ground	<10 Microin.	Ground	Polish	;	to Grit	10 micro- inch	8	400 Grit
	Spec	Size	0.333"ø	0.303"\$	0.333"\$	0.303"\$	0.333"\$	0.303"\$	0.2"	0.250"\$	0.250"	E	F	t
	ne	Speed	7,200	*	:	ε	:	B	1,000#		3,600	E	£	t
	Testing Machine	Kind of Test	Cantil. Bending	ŧ	2	£	E	E	Rotating Cant.	Rotating Cent.	Axial	r	£	:
(p)	ĕ	Type	Westing- house Type MD	E	E	Ε,	z.	E	1	(! !	Special	=	=	E
Heat Resistant Alloys (Continued)		Life, Cycles	108	:	=	=	:	E	2(107)	2×107	2×107	=	=	±
110ys	Fatigue Properties	st. Dev.	ł	:	1	•	1	;	:	;	•	•	i	•
tant A	the Pro	Se Ka1	7,2	84	47	54	54	걸	22	22	₹25	£12	241	1 64
Resig	Fatig	Ka1	No O	t	E	ŧ	E	t	S.	No	N _O	E	E	5 2
1 1		뀪	1.0	2.27	1.0	2.27	1.0	2.27	1.0	1.0	1.0	4.2	3.4	1.0
Table V.		ption	Smooth	Semi-circ. Groove, R = 0.015"	Smooth	Semi-circ. Groove, R = 0.015"	Smooth	Semi-circ. Groove, R = 0.015"	Smooth	Smooth	Smooth	60° V-notch R = 0.022"	60° V-notch R = 0.010"	Smooth With Steady Stress
		Description	Refractaloy 26 Grain Size, ASIM 7-5	Ε	E	£	Refractaloy 26 Grain Size, ASTM 3-5	E	8-816 Alloy	8-816 Alloy	8-816 Alloy (1153)	t	£	" With
		Ref.	पंग	E	8	*	2	t	39	ঞু	04	ŧ	ŧ	:
		Item	3	14	¥	£4	‡	45	3	Ĺŧ	83	6 4	ደ	51
WADI	T	R 60-	42				72							

IAI								
ם מכ			Stati	Static Properties	ties			
r 60	Item	UTS ks1	YP ks1	Elong.	R.A.	Hard.	Chemical Composition	Heat Treatment
-42	<u>ş</u>	!			i	345	N1-35.4, Co-21.4, Cr-18.5, Mo-2.99, T1-2.63, A1-0.14, S1-1.13, Mn-0.86, + Fe	1800°F, 20 min.; 1350°F, 44 hrs.
	14	į	į	ł	į	z	E	ŧ
	क्ष	•	i	i	† •	310	Ε	1800°F, 20 min.; 1500°F, 20 hrs., 1350°F, 20 hrs.
·	143	ŧ	ļ	ł	:	=	T	.
.	3	ŀ	1	i	1 t 2	300	=	2100°F, 60 min.; 1500°F, 20 hrs., 1350°F, 20 hrs.
	45	;	į		! !	z	t	11
73	91	240	67 0.2%	35	59	ļ	C-0.40, Mn-0.70, P-0.014, S-0.016, S1-0.51, M1-20.68, Cr-19.79, Mo-3.46, W-4.46, Co-43.40, Cb-3.80, Fe-2.50	1400°F, 16 hrs., AC.
	Lt	147.3	4. 0.04.3	5,33	1	Rc 27.6	C-0.397, Cr-19.42, Mn-1.12, N1-20.82, S1-0.50, Mo-4.10, P-0.012, S-0.018, W-4.03, Co-42.9, Ch-2.86, Ta-1.03, Fe-2.99	2300°F, 1 hr., WQ; Aged 1400°F, 16 hrs., FC.
· · · · · · · · · · · · · · · · · · ·	9	147.0	74.0 0.2%	ଅ		Rc 27-28	C-0.397, Mn-1.12, 81-0.50, 9-0.018, P-0.012, Cr-19.42, N1-20.62, Mo-4.1, Co-42.9, Fe-2.99, Cb-2.8, Ta-1.03, W-4.03	2300°F, 1 hr., WC; 1400°F, 16 hrs., FC.
	64	=	=		ł	8	Ε	ε
	2	t	2	E	1	ε	ε	ε
	51	E	E	E	•	z	ı.	

WADD				Table V.		Resi	stant A	110%	Heat Resistant Alloys (Continued)	71				
TR						Fatt	Fatigue Properties	pertie		Tes	Testing Machine		Spe	Specimen
60-4	Item	Ref.	Desci	Description	Κŧ	Sm kei	Seksi	St. Dev.	Life, Cycles	Type	Kind of Test	Speed	Size	Surface Finish
S	25	Q.	s-816 Alloy (1153)	Smooth with Steady Stress	ν.τ	524	344	ļ	2x107	Special	Axtal	3,600	0.250"\$	400 Grit
	53	£	z	2	2	*	244	ì	5	:		5	:	8
	**	E	*	*	=	56±	53‡	i	106	t	=	r	τ	ż
	55	z	E	=	=	\$16.	38	;	*	.	=	t	ŧ	=
سسي	95	ŧ	#		=	*111	28‡	1	z	=	=	r	£	E
	57	z	s-816 Alloy s (1153) s	Smooth with Steady Stress	3.4	10#	2 00	ŀ	2×107	Special	Axial	3,600	0.250"	10 micro- inch
	82	ε	t	2	=	5 /4	18±	i	=	•	=	2	8	2
74	59	=	ŧ	E	F	#8#	#27	ļ	2	r	=	:	r	=
	8	ŧ	t	=	E	0	32	!	106	E	t	:	r	400 Grit
	79	E	:	ŧ	2	Ħ	324	1	=	ŧ	E	£	t	10 micro-
	8	E	ŧ	±	:	30	20±	i	•	E	=	:	*	£
	63	Ŀ	£	T T	E	58‡	141	i		=	E	E	I	F
	₫	4	Sandvik Steel.	Smooth	1.0	No	76.0	1	2(107)		Rotating Centil.	1,500	0.37"- 0.38"#	to Grit
	65	=	:	60° V-notch R = 0.0065"	3.9	=	25.0	ŀ	τ	1 1 6 6	=	z	0.375"\$:
	8	ε	E	Smooth	7.0	z	8.0	1	*	1 6 7 8 8	5	t	0.37"- 0.38" ø	400 Grit
	67	z	-	60° V-notch R = 0.0065"	3.9	*	0.4°	ŧ ŧ ŧ	=	# # # #	£	ε	0.375"\$	

			2300°F, 1 hr., WC; 1400°F, 16 hrs., Fc.	ŧ	=	:	•		ŧ	ŧ	ŧ	ŧ	8	E	Normalized 1905°F, AC.	ε	1905°F, 15 min., 0Q; Tempered 1095°F, 1 hr.	ŧ	
Heat Resistant Alloys (Continued)	Observation Commonstitution	CHORTOGET COMBON TOTAL	C-0.397, Mn-1.12, 81-0.50, 8-0.018, P-0.012, Cr-19.42, N1-20.62, Mo-4.1, Co-42.9, Fe-2.99, Cb-2.8, Te-1.03, W-4.03	τ	ī	Ē			z.	E	£	=	£		C-0.98, Mn-0.26, P-0.028, S-0.014, S1-0.22, Cr-1.02, Mo-0.24, Cu-0.02, N1-0.01	·	E	T.	
Table V.	7	nard	Re 27-28	ŧ	z	=	Ε	u	ŧ	ŧ	8	2	*	=	i		•		
ri	ties	7.V		į	ŧ	ţ ! [į		;	ļ	ļ	į	į	•	п	=	ส	=	
	Static Properties	* **	23	•	غر ع		7		2	£	=	r	2	=	6.1 2"	z	ł	i	
	Stat1	i ii	74.0		E		2	=	£	2	E	E	t	=	116.5	=	177	E	
	24	ka1	147.0	E	E	E	x	F	£	g	=	r	*	2	185.7	=	203.7	r	
	į	17	25	53	武	55	96	25	82	59	8	79	8	63	₫	જ	8	29	

	Bpectaen	Burface Finish	es og		•	*	*		Polish	i	o tro	*	\$00 Grift	10 micro-	
	ě	818	Plate						0.2"	0.250"	0.250"		0.250"		
	,	Speed	180 081		8	8	2	*	1,000	:	3,600	8	3,600	8	
	Testing Machine	Kind of Test	Axtal						Rotating Cantil.	Rotating Cantil.	Arial	*	Axiel		
	ę.	Type	Sub- reson.	8	8		8	8		1 1 1	Special	*	Special	=	
Heat Resistant Alloys (Continued)		Life, Cycles	108	8	8	8	8	2	2(101)	20107	20107	106	2×107	=	
lloys	pertie	St. Dev.	•	•	•	:	i			•	ł		ŀ		
rtant A	Patigue Properties	Se Kei	29.5	19.5±	14.5±	ğ	36	184	%	ક	\$	66 t	#S#	\$ ‡	
t Resis	Pett	ke i	27.5± 29.5±	19.5± 19.5±	14.5± 14.5±	ğ	ğ	184	윤	<u>Q</u>	8	ŧ	No.		
1 1		ž,	1.0	2.0	0.4	1.0	2.0	0.4	1.0	1.0	1.0	ε	1.0	2.4	
Table V.		Description	Smooth heet	Edge Notches 0.375" Deep R = 0.3175"	Edge notches 0.375" deep R = 0.0570"	Smooth Sheet	Edge Notches 0.375" Deep R = 0.3175"	Edge Notches 0.375" Deep R = 0.0570"	Smooth	Smooth	Smooth	=	Smooth	60° V-notch R = 0.022"	
		Descr	347 Stainless Steel. 0.064" Sheet	£	r	403 Stainless Steel. 0.050" SI	E	£	Type 403 Alloy	Type 403 Alloy	Type 403 Stainless	£	X-40 (Stellite 31) Alloy, Precision Cast	£	
		Ref.	Str	*	*	2		=	39	Z¥	9	ŧ	8	=	
		Item	89	\$	70	и	22	73	47	2	76	u	87	23	
WADI	D 1	r 60	-42				7	6							

Heat Trestment	Amealed.	=	5	"Heat treated to Rockwell C &O to &l".	\$		1700°F, 15 min., AC; Tempered 970°F to 1020°F, 2 hrs., AC.	1750°F, 15 min., 0Q; 1050°F, 90 min., AC.	1750°F, 15 min., 0Q; 1000°F, 1.5 hrs., AC.	*	Temper 1350°F, 50 hrs., AC.	\$	
Chemical Composition		1			1		C-0.12, Mn-0.37, P-0.016, S-0.022, S1-0.26, N1-0.44, Cr-12.67, Fe-86.1	C-0.110, Cr-12.20, Mn-0.51, M1-0.06, 81-0.34, Mo-0.05, P-0.018, S-0.010, A1-0.03, Sn-0.0089, Fe-bal.	C-0.12, Mn-0.51, S1-0.34, S-0.010, P-0.018, Cr-12.20, M1-0.06, Mo-0.05, Co-0.03, A1-0.009, Fe-bal.		C-0.46, Mn-0.76, S1-0.71, S-0.009, P-0.011, Cr-25.88, M1-10.62, Fe-0.93, W-7.11, Co-bel.		
Hard.	1	ļ		Rc 40-41	=	*	Re 30-36	Re 24-26	Rc 24-26	t	Re 31-41	=	
ties R.A.	1	ł		1	į	:	す	&	ŧ	į	i		
Proper	હ	=	r	80	z	¥	17.5	ส 🕷	ជ	2	11.8		
Static YP ksi	0.86	2	E	153.0		2	138	9.5 18.0	0.721	=	68.0 0.24	=	
UTS ks1	o. %	I	*	190.0	8	=	755	& 1	141.0	£	0.621	E	
i i	8	\$	٤	r L	দূ	ದ	72	K	92	14	81	62	
	Item UTS YP Elong. R.A. Hard. Let kai & \$	Static Properties UTB YP Elong. R.A. Hard. Chemical Composition	Static Properties	Tree UTB YP Elong. R.A. Hard. Chemical Composition	Item UTS YP Rlong. R.A. Hard. Chemical Composition Heat Treatment 68 92.0 45.6 61 Annealed. 69 " " " 70 " " " 71 190.0 153.0 8 Rc +0.0 to 41".	16em UTS YP Elong. R.A. Hard. Chemical Composition Heat Trestment 68 92.0 45.6 61 Annealed. 69 " " " " 70 " " " " " 71 190.0 153.0 8 Rc " " " 72 " " " " " " " " 72 " " " " " " " " " 72 "	1tem UTS YP Rlong. R.A. Hard. Chemical Composition Heat Treatment 68 92.0 45.6 61 Annealed. 69 " " " " 70 " " " " " 71 190.0 153.0 8 Ro "Heat treated to Rockwell 72 " " 40-41 " " 73 " " " " 73 " " " " 73 " " " "	Static Properties Static Properties Static Properties	The UTB YP Elong. R.A. Hard Chemical Composition	Them UTS YP Elong. R.A. Hard. Chemical Composition	Them WHS TP Elongs R.A. Hard Chemical Composition	17em UTB STRAIGH Properties	1542 UTS STRATIC PROPAGRITION

				,	•											
	Specimen	Surface Finish	10 Micro- inch	400 Grit	10 micro- inch	*	Polish	2	too Grit	600 Grift	\$00 Grit	10 micro- inch	E .	-	!	3 4 5 1
	edg	Size	0.250"\$	0.250"\$		\$	0.2"	2	0.250"\$	=	0.250"ø	E	5		!	
	•	Speed	3,600	3,600	E	\$	1,000	ŧ	3,600	E	3,600		5		1	
	Testing Machine	Kind of Test	Axfal	Axial	.	8	Rotating Cantil.	*	Axial	£	Axial	E	ž.	Axial	=	=
7	Ter	Type	Special	Special	r	ž	:		***************************************	0 0 0	Special	E	k	Schenck	=	=
Heat Resistant Alloys (Continued)		Life, Cycles	2×107	2×107		2	2(107)	2	2.6x107	E.	2×107		ŧ	107	=	=
lloys	Patigue Properties	St. Dev.	•	i	ļ		ł	ł	ł	•	ŀ	;	1	ł	1	1 1
stant A	gue Pro	Se ks1	284	芸	244	194	65	Lt	75‡	29‡	28 ‡	ğ	25±	63	נל	8 K
Rest	Fati	Sm ks1	380	z	ŧ	s	SE SE	=	No	r	<u>Q</u>	E	2	SK K	=	=
1 1 1		χ ,	₹.€	1.0	4.6	3.4	1.0	E	1.0	3.4	1.0	4.9	3.4	1.0	E	=
Table V.		Description	60° V-notch R = 0.010"	1 Smooth	60° V-notch R = 0.022"	60° V-notch R = 0.010"	Smooth	2	Smooth	60° V-notch R = 0.010"	loy Smooth	60° V-notch R = 0.022"	60° V-notch R = 0.010"	Room. Temp.	1200°F Tests.	1400°F Tests.
		Desc	X-40(Stellite 31) Alloy, Precision Cast	16-25-6 Timken Alloy	£	=	TP-2-B	TP-2-R	Udimet 500 Alloy	2	6.3% Mo-Wespelloy (A-874)	8	2	Rene 41. Roo	021 "	140
		Ref.	3	2	2	2	39	8	36	8	Q ₄	*	*	94	=	E
		Item	8	81	88	83	ಕೆ	35	88	87	88	89	8	ಚ	81,	8
WADD	TR	60-1	12					78								

Table V. Heat Resistant Alloys (Continued)	Static Properties	YP Elong. R.A. Hard Chemical Composition Heat Treatment kei \$ \$	68.0 11.8 Re C-0.46, Mm-0.76, S1-0.71, S-0.009, Temper 1350°F, 50 hrs., Ac. 0.2% 31-41 P-0.011, Cr-25.88, M1-10.62, Fe-0.93, W-7.11, Co-bel.	30.0 13 Ehn C-0.102, Mn-1.92, S1-0.528, 8-0.009, Fleischman hot-cold work: 0.24 269- P-0.01, Gr-16.45, N1-27.0, No-6.60, Equalize at 1950°F; Reduce 311 N2-0.133, Fe-bal. relieve 1200°F; Stress			104.5 4.5 4.8 Mo-98, W-2 atmosphere.	0 0 Mo-100	14 c-0.08, s-0.006, Al-2.99, Ti-3.03, 1975°F, 4 hrs., AC; 1550°F, Mo-4.30, Cr-19.0, Co-19.3, Fe-0.40, 24 hrs.; 1400°F, 16 hrs., AC. 81-0.11, Mn-0.10, Cu-0.10, Mg-0.01, Mg-0.01, Mi-bel.		96.0 12 Rc C-0.136, Mn-0.56, 81-0.31, Cr-19.68, 1975°F, 4 hrs., AC; 1550°F, 0.2% 35.0 N1-53.3, Mo-6.32, Co-13.55, T1-2.59, 24 hrs., AC; 1400°F, 16 hrs., AC. Al-1.04, Fe-2.5			Solutioned at 1950°F; Aged co-11.0, Ti-3.15, Al-1.75, at 1400°F.		
	Static		68.0 0.24		t	=	104.5			•		t	=			
		UTS test	123.0	120.0	t	r	120	75.5	84 1650°F	=	156.0	=	E	;		1 6 f
		Item	8	81	88	83	ಹೆ	85	%	87	88	&	8	91	84	83

84 A.

	Specimen	Surface Finish				7	;	3	1	!	1	
	oedg	Size		į		1	1	1 1 1		i	•	
	g	Speed cpm		*	-	9			1			
	Testing Machine	Kind of Test	Axial	=	=	=	t	=	z	E	u	
7	Tea	Type	Schenck	£.	Ξ	=	*	Ξ	=	2		
Heat Resistant Alloys (Continued)	g	Life, Cycles	107	2	=	=	=		=	=	11	
Alloys	Fatigue Properties	St. Dev.		ł	1	į	}		}	ł	1	
stant	gue Pr	Seksi	式	43	4.94	64.2 42.8	23.6	37	87	15.4	7.2	
t Resi	Fati	S _m ksi	ક્ર	2	9.69	64.2	35.4	55.5	23	9.19	28.8	
1 1		¥	1.0	=	=	=	=	z	=	=	=	
Table V.		Description	. 1400°F Tests.	1600°F Tests.	Room Temp.	1200°F Tests.	1400°F Tests.	1200°F Tests.	1600°F Tests.	1400°F Tests.	1600°F Tests.	
			Rene 41.	=	=	: 	I	=	:	=	Ŧ	
		Ref.	917	=	=	=	=	=	=	=	=	
·		Item	ま	8	%	97	8	83	8	101	308	
GŒAW	TR	60-	42								80	

		Heat Treatment	Solutioned at 2150°F; Aged at 1650°F.	=	Solutioned at 1950°F; Aged at 1400°F.	=		Solutioned at 2150°F; Aged at 1650°F.	Ε	Ξ		
Heat Resistant Alloys (Continued)		Chemical Composition	Nominal. C-0.09, Cr-19.0, Mo-9.75, Co-11.0, Ti-3.15, Al-1.75, Ni-bal.	± .	=	=	=	=	=	=		
Table V.		Hard.	1	6 1	1	!	!	1	i i	-		
2.1	ies	R.A.	1	;	1	ł	ł	ł	!	i	-	
	Static Properties	Elong.	1	;		i	!	1	į	ŧ		
	Stati	YP ksi	!	1		1 1 1	! ! !	1	ł	i	:	
		UTS ksi		ļ	1	<u> </u>	i	i	ļ	ļ	1	
		Item	ま	8	%	94	88.	86	80	τοτ	102	
WADI	TI	R 60-	42						81			

		Surface Finish			10 micro	1	!	į	-	ŀ	1	ŀ	
	Specimen	Size	∮ 200€•0	0.300" thick	0.400#ø	=	=	E	0.100.0	£	=	=	
		Speed	10,000	1,750	1,800 or 3,600	=	=	=	1 1			1	
	Testing Machine	Kind of Test	Rotating Bending	Rev.Cant. Const.Defl.	Push- Pull	=	=	:	Axial	E	z z	=	
	Jet	Type	R.R. Moore	Krouse	Axial	=	=	2	Schenck	=	z.	E	
Aluminum Alloy 2014 (148)	8	Life, Cycles	108		107	=	=	=	2(107)	=	E	#	
Alloy	Fatigue Properties	St. Dev.	i	•	•	i	;	1		•	1	;	
um i num	gue Pro	Se ks1	20.5	20.0	23	เร	13	6	な	11.5	સ	11.5	
	Fati	S _m ks1	No.	=	No.	=	=	=	=	=	2	=	
Table VI.		K t	1.0	=	1.0	1.6	4.6	3.4					
T.		Description	•		Smooth	Semi-circ. notch. R = 0.100"	60° V-notch R = 0.032"	60° V-notch R = 0.010"	Smooth	60° V-notch R = 0.010"	Smooth	60° V-notch R = 0.010"	
		Descr	Extruded 148-T.	=	Rolled 148-T6.	=	=	=	2014-T6 Longitudinal	Ξ.	2014-T6 Short Transv.	=	
		Ref.	Ltt	5	8म	5	2	=	64	=	=	=	
		Item	п	C)	က	4	2	9	2	8	6:	10	
WAD	D T	R 60-	-42					82					

	Heat Treatment		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Solution 940°F, Age 320°F, 18 hrs.	t _	=	E		•	-	1	
Aluminum Alloy 2014 (148) (Continued)	Chemical Composition	Mn-0.8, Cu-4.4, S1-0.8, Mg-0.6	=	Mn-0.76/0.78, cu-4.19/4.22, s1-0.81/0.83, Mg-0.4c/0.41, Fe-0.5c/0.51, Zn-0.cc/0.01, Cr-0.cc, T1-0.05	t	=	=	850000	1 1	1 1 1 1		
Table VI.	Hard.	i	1	RA 51.3	=	=	=	1	-	:		
FI	ies R.A.		1		į	į	i	ŀ	ļ		i	
	Static Properties YP Elong. R	15.5 (4d)	2	13.6	=	=	=		!	:		
	Station YP XP kei	6.79	=	63.5	=	=	=	l	ł	1		
	UES	75.9	:	72.6	=	=	=	1	!	1	1	
	Item	7	Q	æ	4	2	9	7	80	6	10	

	Specimen	Surface Finish	Politabed	Anodised	Polished, then Cor-	Anod. &Paints. &Corroded	:	1	•	Polished	=	ø 10 micro- inch	1 1 2	1	•	
	đg	Size	0.040" Thick	£	£	=	0.032" × 0.8"	0.032" x 0.5"	:	0.300	0.300" Thick	٥٠،400"	:	=	=	
	ine	Speed	1,800	=	:	=	1,200	% १ १	2	10,600	1,750	1,800 or 3,600	=	=	=	
	Testing Machine	Kind of Test	Rev. Bend.	=	Ξ	=	Axiel	2	=	Rotating Bending	Reversed Cantil.	Push- Pull	r	=	=	
	ī	Type	Somteg	2	=	=	Bruegge- men	Bruegge- man	2	R.R. Moore	Krouse	Axial	z	=	E	
(248)		Life, Cycles	107		=	=	2	107		108	=	107	:	:	=	
Alumimm Alloy 2024 (248)	Fatigue Properties	St. Dev.	1	į	i		38. 94,95	ŀ	%	ł	1	1	:	ł		
un Allo	gue Pro	Se kai	24±	191	204	184	Yes-See Figs.	ង	See Fig. 96	ο· ηΖ	22.5	56	17	ង	30	
Numin	Fati	Sm ks1	SS.	=	=	=	Yes-	8	=	욡	=	£	=	=	=	
VII.		Kt	1.0	=	=	=	2.5	1.0	t	1.0	=	1.0	1.6	4.5	3∙₽	
Table V.		Description	Polished.	Anodized	Polished, then Corroded	Anodized, Painted, Corroded	Alclad 248-T3 Notched. Central drilled hole 1/8"\$	3, Smooth.	Smooth.	8-T".		4 Smooth.	Semi-circ. notch, R = 0.100"	60° V-notch, R = 0.032"	60° V-notch, R = 0.010"	
		Ā	፲-8 42	=	=	:	Alclad 248-T Central dr	Alclad 248-T3, Smooth.	Bare 248-T3, Smooth.	Extruded "245-T"	E	Rolled 248-T4	=	:	=	
		Ref.	50	=	=	=	51	52	£	L+t	*	8 1 1	=	=	н	
		Item	٦	ď	m	4	5	9	7	æ	9	ot	я	21	13	
WAD	D 7	r 60	-42					8	4							

		Heat Treatment		1	!!!	1	Solution; Strain Hardening.	:	E .		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Solution, 915°F.	ε.	:	=	
Aluminum Alloy 2024 (248) (Continued)		Chemical Composition	Army-Mary Spec. AM-A-12	Ξ	=	£	Commercial Grade	E.	2	Mn-0.6, cu-4.5, Mg-1.5	z.	Mn-0.63, Cu-4.17/4.25, Mg-1.42/1.49 81-0.13/0.14, Fe-0.30, Zn-0.07, Gr-0.01/0.02, T1-0.02	•		=	
Table VII.		Hard.	-	į	;	ł	E .	1 1	† †		:	R A 1,8.5	=	3		
E41	les	R.A.	i	ł	ļ	ļ		ļ	i		•	i	i	į	1	
	Static Properties	Elong.	ŀ	!	ł	ł		į	:	19.0 4D	=	21.4	=	=		
	Static	YP	i	ļ	ł	ŀ	50, Tens.	50, Tens. 46, Comp.	56,Tens. 50,Comp.	65.4	=	18.6 0.24	E	=	2	
!		UTS kei	-	;	!	ŀ	67,Smooth 60,Notch	4.79	73.6	₹. 48	=	72.8	=	=	н	
		Item	τ	a	က	#	2	9	~	8	6	70	7	ង	13	
WADD		Item	ч				1									

	Specimen	Surface Finish	i	Electro- Polish	*	8	8	No. 0	Beery Thread	*	Buffed	E	:	
	Bpec	8126	0.09" x 1.5"(1)	*	B	5	*	0.335"≸	0.355"₽	\$	0.295"∳	5	2" x 17" x 0.09" approx.	
	9	Speed	1,100 to 1,500	=		E	2	10,000	=	E	8,000 8,000	=	See Text	
	Testing Machine	Kind of Test	Axial	=	=	=	E	Rotating Bending	=	:	Push- Pull	=	. Push- Pull	
ed.)	Ter	Type	Krouse	z.	E	=	:	R.R. Moore	2	æ	Schenck or Amsler	2	Sub-reson. or Hydr. Jack	
Aluminum Alloy 2024 (248) (Continued)	10	Life, Cycles	101	2	=	3	=	107	2	=	701	t	107	
4 (248	Fatigue Properties	St. Dev.	1	1	•	į	!	ļ	ŀ	ļ		ļ	!	
oy 202	ne Pro	Se ksi	સ	16.5	<u>.</u>	7.5	6.0	81	91	0,	24.6	इ.अ	ž‡	
wm All	Fati	Sm kei	No	=	=	t	1	No.	2	=	Š	:	No	
Alumi		χ. Υ	1.0	1.5	2.0	0.4	5.0	7.0	1.6	3.1	1.0	2.5	0.4	
Table VII.		Description		Semi-circ. Notch, R = 0.760"	Hole, Rdge Notch & Fillet	Edge Notch & Fillet	Semi-circ. Notch, R = 0.031"	Smooth	Semi-circ. Notch, R = 0.062"	45° V-notch, R - 0.01"	Smooth	Drilled Hole, 0.118" \$	Milled Notch, 0.378" Deep, R = 0.0570"	
		Desc	Sheet 248-T3.	=	=	E	E	Hot Rolled 248-T4.	=		Extruded Bars, 248-T	=	248-T3 0.090" Sheet	
		Ref.	9,10, 53, 54	E	2	:	£	55	:		95	=	57	
		Item	₹ 7	15	16	17	18	13	8	21	83	જ	†Z	
WAD	D T	R 60-	-42				86							

		Heat Treatment			!	1		Anneal 660°F, 15 min.; Solution 915°F, 45 min.; Age 250°F, 24 hrs.	r		(Not given in the reference)	=	Т3	
Aluminum Alloy 2024 (248) (Continued)		Chemical Composition	Commercial Grade.	=	2	•	2	Mn-0.69, Cu-4.70, Mg-1.54, S1-0.16, Fe-0.27, Zn-0.03, Cr-0.06, T1-0.03, N1-0.01	=	2	Mn-0.4, Cu-4.1, Mg-1.0, S1 < 0.4, Fe < 0.45, Zn < 0.10, T1 < 0.03	=	(Not Given in the Reference)	
Table VII.		Hard.	i		1	t I I	!	76	\$	=	1	!	:	
51	se,	R.A.	i	ł	ł	ł	ŀ	ł	!	ŀ	7.	=	1	
	Static Properties	Elong.	18.2	=	=	=	:	17.71 04	:	.		ł		
	Stati	YP ket	衣	=	=	=	r	58.0	=	I	55 ±		-	
		UTS	73	=	E	E	*	70.5	r	=	11	=	88	
		Item	77.	15	91	71	18	19	8	2	શ્વ	53	77	
WADI	TI	₹ 60-	42						87					

	4	Surface Fiels		- T	•			8	*	
	Specimen			•	•	Ī				
	6	8120	Plate	8	t	=	•३ ॰ 1त	=	*	
		Speed	į	ļ	1		180	=	8	
	Testing Machine	Kind of Test	Const. Def1.	=	E	E	Axial	=	E	
	ŭ	Туре	Krouse	2	.	#	Sub- reson.	=	:	
Alumimum Alloy 6061 (618)		Life, Cycles	107	=	=	#	101	=		
oy 606	Fatigue Properties	Bt. Dev.	i	į	į		•	;	•	
VM A11	ue Pro	Se kei	14.5	껅	8.5	6.7	13.5	7.5	a	
Alvmin	Patig	8m ksi	No	24	S.	6.7	13.5	7.5	#	
III.		K	1.0	=	2.5	=	1.0	QI	4	
Table VIII.		Description	Smooth	E	Edge Notches 0.7" deep, R = 0.100"	2	Smooth	Edge Notches 0.375" deep, R = 0.3175"	Edge Notches 0.375" deep, R = 0.0570"	
		Descr	618-T6 "as received"	z.	=	=	618-T6 as received 0.125" sheet	t		
		Ref.	8%	:	=	z	54	2	2	
		Item	τ	Q	m	4	5	9	7	
WAD	D T	R 60-	42				88			

	Heat Trestment	Precip. Hardened.	•	=			***************************************		
ontimed)		Prec	·	,					
VIII. Aluminum Alloy 6061 (618) (Continued)	Chemical Composition	Cu-0.25, Cr-0.25, 81-0.6, Mg-1.0		=	=			!	
Table VIII.	Hard.	•	!	!			!	!	
	ies R.A.	1	ł	•	ļ	ł	!	1	
	Static Properties YP Elong. R ksi \$	212	=	=	=	17	2	=	
:	Static YP ksi	0 1 00.0	E	=	=	3	=	E	
	UTS kei	£4	=	=	=	L†t	=	±	
	Item	٦	Q	٣	<i>‡</i>	5	9	~	
WADD	TR 60-4	2						8	

	2.0	Surface Finish				10 stero-	*	20 mtare- inch	8	*	=	10 miero- inch	E	micro- inch		
	Specimen	Size Ou	0.032" × 0.8"	0.300"\$	0.300" Thick	στ '/τ	=	1/4" x 20 1/4"	1/4" Thick	1/4"x3/4"	"#/Lx"8/L	στ "+/τ	1/4"	1/4"x1/4" 20 micro- inch	1/4" Thick	
	9	Speed	1,200	10,600	1,750	=	3,450 6 10,000	1,750	:			r	3,450 6 10,000	1,750	=	
	Testing Machine	Kind of Test	Axial	Rotating Bending	Cent. Const. Defl.	=	Rotating Bending	Const. Const. Defl.	=	=	=	I.	Rotating Bending	Cent. Const. Defl.	=	
(758)	Tes	Type	Bruegge- men	R.R. Moore	Krouse	r	R.R. Moore	Krouse	2	E	t	=	R.R. Moore	Krouse	=	
Aluminum Alloy 7075 (758)	1	Life, Cycles	110,011	308	2	н	F	=	:	=	t	=	=	=	z	
um from	Fatigue Properties	St. Dev.		•	•	1	;	1	!	ļ	:	1	;	ł	i	
	gue Pro	Se ksi	- See Figs.	81	8	83	52	ส	13	33	ध्र	23	83	&	83	
Table IX.	Fati	Sn kei	Yes	S.	=	=	=	=	=	=	=		:	=	=	
EII		κŧ	2.5	1.0	=	¥	=	=	=	*	=	=	:	2	=	
		Description	Alclad 758-T6, Notched, Central Drilled Hole, 1/8"\$	ę.		Plate 758-T6. Longitudinal Specimens	£	T	=	2	a	. Transverse Specimens	=	:	e e	
		ă	Alcled 758-T6, Central Drille	Extruded 758-T	=	Plate 758-16	2	=	=	*	=	Plate 758-T6.	=	E	£	
		Ref.	51	Lħ	=	Ξ	E	=	:	2		2	:	=	ŧ	
		Item	τ	8	က	4	5	9	2	80	6	01	ជ	ผ	13	
WAI	י סכ	rr 60	-42					90								

	Heat Treatment		Not Given.	T.	Solution 916°F to 920°F; Age 210°F, 6 hrs.; Reheat to 10 hrs. 315°F; AC.	ŧ	=	=	#	±	ŧ	=	Ξ			
Aluminum Alloy 7075 (758) (Continued)	Chemical Composition	Commercial Grade Alclad 758-T6	Mn-0.2, Cr-0.3, Cu-1.6, Mg-2.5, Zn-5.6	**	Ma-0.30/0.10, cr-0.40/0.15, cu-2.0/1.2, Mg-2.9/2.1, zn-6.1/5.1, Ti-0.20, Si-0.5, Pe-0.7	=	=	=	=	11	=	=	=	=		
Table IX.	Hard.	9) (1	:	1	!	i	1	-	:	!		}		
81	R.A.			ŀ		į	} !	į	į	1	i	1	ł	!		
	Static Properties YP Elong. R		14.0 40	E	0.11 04 04	2	17 2".	=	=	=	11.0	2	11.7	=		
	Static YP ksi	71, Tens. 66, Comp.	777.7 0.24	.	±.76 0.08 13.08	=	77.0	=	ŧ	=	72.9	=	72.3	=		
	UTS ksi	78, Smooth 77, Notch	87.6	=	₹.48	=	84.2	:	*	=	4.28	2	82.2	=		
	Item	1	N N	m	4	5	9	2	ω	٥	ន	п	ង	13		
WADD	TR 60-4	2					91						·····		 	

	Ÿ.			1											
	T T T T	Surface Finish	1	Klectro- Polish	8	=	8	No. 0	Beery Thread	t	3/0		3/0	2/0	
	Specimen	Bize	0.090" x 1.15"	0.090" × 1.5	=	z	2	0.335"∳		E	0.300"\$	0.330"	0.300"\$	0.15"ø	
	•	Speed	1,100 to 1,500	1,100 to 1,500	=	=	*	10,000	=	*	3,500	=	=	10,000	
(P)	Testing Machine	Kind of Test	Axial	Axial	2	=	=	Rotating Bending	=	2	Rotating Bending	=	=	Beem	
(Continue	Test	Type	Krouse	Krouse	=	2	=	R.R. Moore	=	=	R.R. Moore	=	=	Rot. Cent.	
Aluminum Alloy 7075 (758) (Continued)		Life, Cycles	107	701	=	=	=	107	=	=	101	E	E	107	
* Alloy	Patigue Properties	St. Dev.	•	:	i	ł	i		i		1	;	ł	:	
Aluminu	gue Pro	Se ksi	30	17	15.5	7.5	6.0	25	97	12.5	53	ង	%	ક્ષ	
1 1	Fati	Sm ksi	%	S.	=	=	=	S S	=	=	No	=	=	S.	
Table IX.		Kŧ	1.0	1.5	5.0	0.4	5.0	1.0	1.6	3.1	1.0		1.0	1.0	
EI		Description	Sheet, Smooth	Semi-circ. notch, R = 0.760"	Hole, Edge notch, fillet.	Edge notch, fillet.	Semi-circ. notch, R = 0.031".	Hot rolled 758-Th. Smooth.	" Sem1-circ. notch, R = 0.062".	" 45° V-notch R = 0.01".	Rolled & Drawn Smooth. Rod 758-16	" 60° V-notch R = 0.0002"	Extruded Bar Smooth. 758-16	758-T Smooth.	
		.Ref.	53 8	9	9	=	- 유	55 1	=	=	59 1			23	
	_	Item .R	14	15	- 91	17	9 7	139	&	22	83		#Z	25	
WAD	ת ת	r 60	ł	L			· •	<u> </u>	92						

1)		Heat Treatment			-	1	1 1 1	780°F, 15 min., AC; 450°F, 30 min.; 915°F, 45 min.; Age 250°F, 24 hrs.			7.E	=	=	Tested as received.		
IX. Aluminum Alloy 7075 (758) (Continued)		Chemical Composition	Commercial 758-T6 Sheet.	=	=	=	5	Mn-0.01, Cr-0.23, Cu-1.62, Mg-2.50, Zn-5.44, Ti-0.02, Si-0.11, Fe-0.17, Be-0.001		E	Cr-0.03, Cu-1.6, Mg-2.5, Zn-5.6		:	Mn-0.3, Cr-0.15/0.40, Cu-1.2/2.0, Mg-2.1/2.4, Zn-5.1/6.5, T1-0.2, S1-0.5, Fe-0.7		
Table IX.		Hard.			1	1	:	8 8	=	=	i	1	!	Ban 178.5		
	ies	R.A.		į	ļ	ł	ł		1	1	i	:	ļ	31.6		
	Static Properties	Elong.	11.4	=	=	=	=	₹. 6	=	:	1	1	1	26"2		
	Static	YP ksi	76 0.2%	=	Ħ	=	=	#	=	=	;	1	;	73.1 0.2%		
		UTS ksi	82.5	z	2	2	2	ౙ	=	=	i	j	;	83.7	 	
		Item	14	15	16	17	18	13	8	ผ	83	83	†Z	25		
WADD	TR	60-4	2						93						 ·	

	d e	Surface Finish	2/0			1	\$ \$ 1		
	Specimen	Bire	0.15" ø	2.25" x 16.89" x 0.090"	0.100 " ø	=	=	I	
	9	Speed	8,000	See Text	1	!	1 1		
(2)	Testing Machine	Kind of Test	Beam	Axial	Axial	=	2	tr .	
Aluminum Alloy 7075 (758) (Continued)	Test	Type	Rot. Cent.	Sub-res. or Hyd. Jack	Schenck	z	z	24	
7075 (75		Life, Cycles	נג	ىد	2x107		=	2	
n m Allo	Patigue Properties	øt. Dev	See Text	See Text	;	i	;	ļ	
Alumin	gue Pr	Se ksi			25	ជ	8	ជ	
ž.	Fati	S _m kei	£	No	No	=	=	=	
Table IX.		ጟ	1.0	0.4	1.0	4.5	1.0	4.5	
6		Description	Smooth.	Milled Notches 0.0375" Deep. R = 0.0570".	Longitudinal	=	Short Transverse	=	
		Desc	7/8" Bar Stock	0.090" Sheet	70758-T6 Hand Forged	=	2	=	
		Ref.	8	57	64	=	:	=	
		Item	%	23	38	&	30	31	
WA	DD	TR 6	0-42					94	

### Beatle Properties UNS		Heat Treatment				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		
### Not Properties	Aluminum Alloy 7075 (758) (Continued)	Chemical Composition			* () e & * = 1	!		
2 8 8 8 E	- 1	Static Properties YP Elong. R.A.	83.7 73.1 16 31.6 0.2% 2" 31.6	98			:	

							-					 					
	nen	Surface Finish	3/0 Bery			=	2	*		=	8	2/00 Beery	2	=	E	E .	
	Specimen	81ze	0.26" ø		=	=	=	=	=	=	=	0.26" ø	0.14" ø	0.26" 🌶	0.25" x 0.25"	1/4" × 3/4"	
	8	Speed		į		1	;		1	!	8 8 9	6,000	13,000	1,750	E	=	
	Testing Machine	Kind of Test	Const. Def1.	=	=	=	=	E	=	=	=	Rotating Bending	=	Cantil. Bending	=	=	
(168)	Te	Type	Krouse	=	=	Ξ	=		F	a a	=	Krouse Cantil.	Special	Krouse Vib.	=	=	
Aluminum Alloy 7076 (768)	a	Life, Cycles	108	=	=	=	2	=	=	2	5	108	2	=	=	±	
unui.	pertie	St. Dev.	ŀ	;	ł	i	-	ŀ	ļ	:	}	i	ļ	! !	ì	•	
1 1	Fatigue Properties	Seksi	24.5	23	12	80	19	16 Tors.	14.5 Tors.	12 Tors.	8 Tors.	8d	25.2	† ₹	18.5	16.5	
Table X.	Fatig	S _m ks1	£	껅	30	45	8	No	12 14.5 Tors. Tors.	30 12 Tors. Tors.	45 Tors.	No.	=	=	=	=	
138		ጟ	1.0	±	=	=	=	=	=	=	=	1.0	=	=	=	=	
		Description	Bending	2	2	=	2	Torsion (Ult. Str., Shear, 60 ± ksi)	=	=	=	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	1 1 2 2 3 4 5 5	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	\$ P P P P P P P P P P P P P P P P P P P	1 1 1 5 6 6 1 1 1	
		Ref.	19	:	=	=	=	=	=	=	:	8	=		=	=	
		Item	н	a	က	#	2	9	7	æ	6	9	ជ	엄	£1	켰	
WADD	TF	२ 60-	42							96			-				

20.00

	Heat Treatment	Solution 860°F, 10 hrs., WQ;	t	F	=	r	=	=	£	2	=	z	=	z	=		
Aluminum Alloy 7076 (768) (Continued)	Chemical Composition	Cu-0.6, Zn-7.6, Mg-1.6, Mn-0.5, T1-0.1, Fe-0.5, S1-0.25	=	=	E	=	10	2	2	=		r	E	=	=		
Table X.	Hard.	1	ŀ	i	i	1	1	1 1	;	:	3hn 346	=	=	:	=		
티	B.A.		;	;	ļ	;	;	;	!	ł	9.04	=	=	=	=		
	Static Properties YP Elong. R ksi %		;	ļ	;	;	ļ	į	;	ļ	19.2 2"	=	=	E	=		
	Static YP ksi	67	=	2	2	2	E	=	=	=	67 82.0	=	=	=	=		
	UTS	73	=	2	t		Ħ	=	*	E	73	=	2	=	=	 	
	Item	1	αı	က	. #	5	9	7	ھ	6	OT.	я	ឧ	£	1 7		
WADD	TR 60-	42							97								

4			4	,-,-,-,-,-,-	_							
	laen	Surface Finish				;) () () ()	;	2-3 Micro- inch		
	Specimen	8128	0.30" \$	0.300" x 3/4"	8	*	t	ŧ	E	0.230"\$	5	
	2	Speed	9,000	1,750	=	*	ŧ	=	:	12,000	E	
ন	Testing Machine	Kind of Test	Rotating Bending	Centil. Bending		r	=	=	=	Rotating Bending	3	
Aluminum Alloy 7076 (768) (Continued)	Te	Type	Krouse Centil.	Krouse Vib.	2	E	E	=	2	R.R. Moore		
7076 (768)	**	Life, Cycles	108	=	=	=	=	E	#	5(108)	Prot	
n Alloy	Fatigue Properties	St. Dev.	1	•	ŀ	!	ł	5.75	į	1.6	1.3#	
umitan	ue Pr	Sek	8.8	7.5	8.5	8.0	6.5		4.5	53	31.5	
1 1	Patie	S. kei	No.	E	-8.5	0.4	6.5	10.75	14.5	M		
Table X.		χ.	2.6	3.6	=	F	=	E	E	1.0	R	
		Description	60° V-notch, R = 0.01".	=	2	*	z	=	=	7/8" Ø Bars.	t .	
		Ref.	જી	=		5	3	=	r	83	=	
		Item	15	J 6	17	ध्य	13	8	ส	81	83	
IAW	ם כו	rr 60	-42							98		

		Heat Treatment	Solution 860°F, 10 hrs., WQ; Age 275°F, 12 hrs.	2	=	E	2	.=	=	Heat treated by wendor.		
Aluminum Alloy 7076 (768) (Continued)		Chemical Composition	Cu-0.6, Zn-7.6, Mg-1.6, Mn-0.5, T1-0.1, Fe-0.5, S1-0.25	Ε	=	=	2	=	=	Cu-0.63, Mn-0.48, Fe-0.45, S1-0.20, Mg-1.47, Zn-7.18	Ē	
Table X.		Hard.	Bhn 146	Ξ	=	=	E	=	=	8 69	2	
H	1es	R.A.	9.04	=	=	=	E	r	=	30 ±	=	
	Static Properties	Elong.	19.2 2"	=	=	=	=	=	=	16 ± 40	=	
	Static	YP ksi	67 0.2%	=	=	=	=	=	2	88.0	=	
		UTS ksi	73	=	=	=	=		=	76	=	
		Item	15	16	7.7	भू	91	8	ผ	જ્ઞ	23	
WADI) TF	₹ 60-	42							99		

i, i			[
	Specimen	Ourface Finish					
	Spec	8120	0.100"	æ	£	2	
	92	Speed cpm	i				
	Testing Machine	Kind of Test	Axial	E	=	#	
	Per	Type	Schenck	2	3	п	
Teble XI. Aluminum Alloy 7079		Life, Cycles	2×107	u	*		
tomitmum	Fatigue Properties	Bt. Dev.	ŀ		1		
7	Se Pro	e i	র	п	ส	ជ	
ble XI	Fatig	San kei	욡	=	=	=	
		K.	1.0	2.4	1.0	2.4	
		Description	Longitudinal	=	Short Transverse	*	
		Des	Hand Forged.	2	2	=	
		Ref.	64	E	8	=	
		Ite	7	લ	က	4	
WADD	TR	60-	12				100

	Heat Treatment		t 1	1 1		
. Aluminum Alloy 7079 (Continued)	Chemical Composition	Mominal. 81-0.30, Fe-0.40, Cu-0.40/0.8, Mn-0.10/0.30, Mg-2.9/3.7, Cr-0.10/0.25, Zn-3.8/4.8, T1-0.10, Other-0.15.	=	В	=	
Table XI.	Hard.	1	i	•	1	
	ties R.A.		į	:	ł	
	Static Properties YP Elong. R		•	ŧ	:	
	Stati YP kei		1	1	i	
	UTS ks1	l	!	ŀ	i i i	
	Item	ч	ય	3	#	
WADD	TR 60-	42				101

	1	Surface Plates			•		!			1		:	t t	
	Specimen	Bize	1/2" x 0.25"		1 1/4" x 0.25 1/4" hole		0.094" Thick 1/4" hole		0.094" Thick No Hole		0.04" Thick No Hole	B	B	8
	8	Speed	4 0 3	1					1		. !			
	Testing Machine	Kind of Peet	Const. Defl. Cantil.			•		•	•	•	•			•
	F	8	Lrouse		s		:	2	*	8	*		*	*
Lloye		Life, Orches	107	8	8	*		*	*	¢	*	8		*
Magnesium Alloys	Patigue Properties	ă ă		:	•	:		! !	:	; 9		L	4.75	:
	1 8	86 A	13.2	9.7	0.01	7.7	75.2 र	4.6	12.5	9.11	1.5	7.01		•
Ė	Pett	2 2	욮						2		•	*	4.73	•
Table XII.		*	1.0	=	••		•	•	1.0	•		=	*	*
		Description	Not coated.	Anodie HAE conting. 0.0025" thick.	Not coated.	Anodic HAE conting. 0.0025" thick.	Not conted.	Anodic HAE conting. 0.0025" thick.	Not conted.	Amodic HAR conting. 0.0015" thick.	Not coated.	Anodic EAE conting. 0.0015" thick.	Not coated.	Anodic HAE coating. 0.0015" thick.
			M31X.	8	*	8		E	•	8		*		2
		j	જ	*	*		R	8	*		8			2
		1	п	QI	m	*	^	vo	۲	۵	٥	ន	я	2
WAD	D T	R 60-	42				10	2						

	Best frestment	20000												
Table XII. Magnesium Alloys (Contimued)	Chemical Composition	Al-3.0, Zn-1.0, Mn-0.3	E	•	E	Ē	•	£	E	ŧ	•	E	*	
q	Hard.		;	i	i	!	!	i	ł	!	•	!	;	
	Eilee R.A.	!	į	ļ	į	ł	į	ļ	i	į	ļ	į	ļ	
	Static Properties YP Elong. R., kei \$ 5		į	į	;	1	•	•	i	1	•	i	:	
	Static TP Est	1	į	į	ļ	į	i	į	į	į	i	;	į	
			i	ł	ł	ł	i	į	ł	ł	į	;	;	
	Item	п	Q)	m	.4	ľ	•	~	σο	٥	ន្ទ	я	24	
WADD	TR 60-4	2					103	3						

14 14 15 15 15 15 15 15	WADD				Table XII.		secos,	tun A11	oys (Co	Magnesium Alloys (Continued)					
13 64 789-1h Smooth 1.0 7.6 7.8 10 ⁷ 7.79 7.84 6494 648	TR						Patie	F P.	perties		Ž	ting Machin		8	free
13 64 79-1h Smooth 1.0 7.8 7.5 10 ⁷ frome Cant 0.0684 14 1	60-4	Item	Bef.		Description	2	15 gr	Se is	9t. Dev.	Life, Cycles	fype	Kind of Test	Speed	Bise	Surface Finish
14	2	ຄ	3	76-1h (AZ31X)	Smooth	1.0	7.8	7.8	i	101	Krouse	Cent. Bend.	i	0.064°	•
15 " " Smooth 1.0 14.4 8.6 " " Arial " " 17 " Smooth 1.0 19.5 6.5 "		ત્ર		8	60° V-notch, 0.003" deep, R = 0.001".	8.0	7.5	7.5	1 1 1	2		•			1
16 " " Smooth 1.0 19.5 6.5 " " " " " " " " " " " " " " " " "		2,5	*	*	Smooth	1.0	4.41	9.8	:	*		Axtal	!	*	1 1
17 " " 60" V-mortal, 0.003" 2.0 10.9 6.6 "		श्र		ŧ	Smooth	1.0	19.5	6.5	i				1		! !
19 " Bage Notches, 1.6 6.5 6.5 " " Ount: 0.080° 1.6 6.5 6.5 " " Thick Bond. 1.0 0.080° " " Thick Bunch Bondh 1.0 6.8 6.8 " " " 1.0 0.084° " " Thick Bunch Bunch 0.003" 2.0 6.5 6.5 " " Attal " 1.0 13.1 7.9 " " Attal " " Thick Bunch Bunch 0.003" 2.0 10.6 6.4 " " Attal " " " 19.5 6.5 " " " Attal " " " 19.5 6.5 " " " " Attal " " " " " 19.5 6.5 " " " " " " " " " " " " " " " " "		22		*	60° V-notch, 0.003" deep, R = 0.001".	9.0	10.9	9.9	ì	8			•	•	1
20 " FB-1a Baooth 1.0 6.8 6.8 " " " 0.064" 21 " G0" V-notch, 0.003" 2.0 6.5 6.5 " " " 0.064" 22 " " Smooth 1.0 13.1 7.9 " " " Axial " 23 " " Smooth 1.0 13.1 7.9 " " " Axial " 24 " " G0" V-notch, 0.003" 2.0 10.6 6.4 " " " " 25 " " Smooth 1.0 7.8 7.8 " " " " 26 " " Bige Motthes, 1.0 7.8 7.8 " " " Court 0.080" 26 " " Bige Motthes, 1.6 6.5 6.5 " " " " " " " " 26 " " Bige Motthes, 1.6 6.5 6.5 "		83	*	ŧ	Smooth	1.0	9.6	9.6	•	8		Cent. Bend.		0.020°	
FF-1a Smooth 1.0 6.8 6.8	104	19	*	#	Edge Hotches, R = 0.125"	1.6	6.5	6.5			=	=		•	
60° V-notch, 0.003" 2.0 6.5 6.5 " " " Axial " " " Axial " " " Axial " " " Axial " " " Axial " " " Axial " " " " Axial " " " " Axial " " " " Axial " " " " Axial " " " " " Axial " " " " " " " " " " " " " " " " "		8	¥	FS-la Sheet	Smooth	1.0	6.8	6.8			8	*		0.064" Thick	
		ส	2	ŧ	60° V-notch, 0.003" deep, R = 0.001"	9.0	6.5	6.5	•				:	t	1
" " 60° V-notch, 0.003" 2.0 10.6 6.4 "		ผ			Smooth	1.0	13.1	4.9	;	E		Axial	:		1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
" " 60° V-notch, 0.003" 2.0 10.6 6.4 " " " " " " " " " " " " " " " " "		જ	E		Smooth	=	19.5	6.5	;				*	*	
" " Sage Motches, 1.6 6.5 6.5 " " Cent. Bend. " " Bdge Motches, 1.6 6.5 6.5 " " "		ね	8	*	60° V-notch, 0.003" deep, R = 0.001".	9.0	10.6	4.9	•			•	1		1 1 1
" Bdge Motches, 1.6 6.5 6.5 " " "		80			Smooth	1.0	7.8	7.8	;	*	=	Cent. Bend.	!	0.020" Thick	1
		%		2	Edge Motches, R = 0.125".	1.6	6.5	6.5	•	E	E			ŧ	

2		=======================================					Item UTS IP Elong. R.A. Bard. Chemical Composition Hest freshment kei kei \$ \$, R-64/31
	-		37 22 21 12				35± 8± Al-3.0, Ma-0.3, Za-1.0 (nominal) " " Al-3.0, Ma-0.3, Za-1.0 (nominal) " " " " " " " " " "	175 179 170
							35± 8± Al-3.0, Mn-0.3, Zn-1.0 (nominal) " " " " " " " " " " " " " " "	UFB IP Elong. R.A. Hard. Chemical Composition 33 354 8 4
						•		UES IP Elong. R.A. Hard. Chemical Composition ksi ksi ksi \$ \$
				•	*		Flong. R.A. Hard. Chemical Composition	

	_					_					_							
	Specimen	to Surfees Finish	17°	0.300"s 3/0 and mores.	0.295"\$	¥0,0		•		0.295"\$	1	1		0.300"¢	•	•	1	
		8120	0.117 Phick		%; •	0.250"	=	*	*	0.8 0		E	3	0.3		*		
	hine	Speed	ļ	;	;	i	į	į		1 1 1	1	•	;	•	;	į	****	
	Testing Machine	Kind of Test	Cent. Bend.	Rotating Bending		3	=	*	2	t .	*	z.	*	t		*	*	
		Type	Krouse	R.R.	*	2	*		ŧ	1	E	:	t	E		=	*	
Megnesium Alloys (Continued)		Life, Cycles	Tot	*		8	8	=	*	2	£		#	F	2	g	=	
) s.c o	pertie	St. Dev.	ŧ	į	•	ŧ	į	i	ł	;	}	ļ	-	1	ł	į	•	
tum Al	Fatigue Properties	Se kei	5.0	21.0	30.5	16.5	16.0	15.0	14.5	13.5	10.0	9.5	8.5	6.5	6.0	5.0	5.0	
Section	Peti	Ket Mark	5.0	2	E		t		*	=			*	F	*		=	
1 1		7,	1.0	2	0.0	1.0	٤.	=	ŧ	2.0	E	ε	t	5.0	E	ŧ		
Table XII.			e, Smooth	2	Semi-circ. Notch, R = 0.030"	Smooth	T	£	#	Semi-cire. Motch, R = 0.030"	2	F	м	60° V-notch 0.09" deep, R = 0.002"	8		2	
		Description	Grain Size, 0.003"-0.008"	ŧ	*	Sand Casting.		ŧ	=	z	t		2	Ł			2	
			FB-1 Sheet Extrusion	8	s	C-III Sand	C-HTA	C-HTG	C-AC	ж- -0	C-1878	C-EEA	C-AC	SLEE-O	PH -	C-IFFA	C-AC	
		Ref.	ತ	ŧ		*	2	8	2								8	
		Ite	22	84	&	30	ж 3	8	33	*	35	36	37	38	39	2	141	
WADD	<u> </u>		2			L			10	6						-		

	Heat Trestment		•	!			!	•	1	\$	1						
XII. Magnesium Alloys (Continued)	Chemical Commonition		Al-3.0, Mn-0.3, Zn-1.0 (Nominal)	•	E	Al-9.0, Mn-0.1, Zn-2.0	E	ŧ		=		•		•	E	E	£
Table XII.	Harri		-	1	•	i	1	!	# **	i	i	;		ŧ	; !	:	:
	ties P.A.	*	:	;	1	ļ	1	•		ł	i	i		9	:	•	•
	Static Properties	*	15		2	o r	αı	m	ĊV	οτ	m	Q	N	m	20	(VI	cv
	Stati	red Fed	8	=	*	91	ន	8	Ħ	91	8	ଷ	47	8	97	જ	14
	Į.	kei Lei	O¥		2	•	2	8	₹	Q q	=	t	†	Ş	ŧ		₹
	ļ		12	88	83	30	æ	84	33	₹E	35	%	37	82	39	3	1.4
WADD	TR (60-1	1 2					1	.07								

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	Lasa	Surface Finish	•		•	!	1			10 micro-			900 Grit	-	600 Grit	
	Bpectmen	Sise	0.250*	0.295"∳	1.000" × 0.064"	*	2		*	0.400"¢	0.400" Root	*	0.6" ±	0.584"	0.172" Thick	
	trae	Speed		•	1,500		*	3	t	3,600		t	1,500		1,500-	
	Testing Machine	Kind of Test	Rotating Bending	•	Axial		z		2	Push- Pull		2	Rotating Cant.	a	Axdel	
		Type	R.R. Moore	2	Krouse		.	•	2	Axial	ŧ	*		-	Krouse	
ontinued)	•	Life, Cycles	107	#	101	*	*	2	5	701	g	H	2(107)	*	701	
10ys (C	Fatigue Properties Sa Sa Sa Sa Sa Sa Sa S															
tum Al																
Magne	Pats	E.S.	£	t		14.5	ส	25.5	37	욢	=			#	Ж	
1 1	3 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0															
Teble X	Table XII. Smooth 1.0 ch, 0.030" 0.75 1.0 0.60 " 0.50 " 0.05 " th 1.0 th 1.0 th 3.9 0.010" 1 Loeding 1.0															
	C-HTA Perm. Mold Gasting. 1 FS-1h, Hard R: R: R: R: R: R: R: R: R: R:															
		Per.	ඡ	£	65		*	=	*	8		2	.44	*	67	
		15 15 15 15 15 15 15 15 15 15 15 15 15 1	3	43	\$	3	2	14	9	64	8	נצ	25	52	45	
WADD	TR	60-1	12						108							

	Heat Treatment					İ	ļ		Extruded at 625-680°F, 5-7 ft. p. min. Aged 24 hrs. at 300°F.	F		(Extruded bars, need "as is")	T.	Stress Relieved 500°F, 15 min., AC.	
Table XII. Magnesium Alloys (Continued)	Chemical Composition	A1-9.0, Mn-0.1, Zn-2.0	22	Al-2.8, Mn-0.3, Zn-1.0 (nominal)	E	E	t	tr.	Zn-5.6, Zr-0.66, + impurities	2		Al-7.2/5.8, An-0.4/1.5, Si-0.3 max., Ma-0.15 min., Cu-0.05 max., Fe-0.005 max.		As specified by ASM.	
Table	Hard.	ŀ			ļ	ļ	i	i	:	i	† 1	:		DPH 58 2.5 kg	
	ties R.A.		•		1	:	:	i	ł	{	•	i	•	5.44	
	Static Properties YP Elong. R.: ksi \$ \$		i	## %	t	t		r	21.4			14.5	t	3.4	
	Static YP kei		i	35±	z	2	2	E	0.03 0.03	£	:	33.5	=	4.22	
	UTS ks1	1	•	# 2 #		±	t	2	47.5	=	*	η 6 .0	=	36.8	
	Item	24	£ 1	3	3	2	74	8	64	8	15	25	53	式	

	=	Derribes Plates	600 Gr.14	•		•				Machine	3				
	Specta	Bise	0.235" Thick		0.172" Thick	0.300"\$	0.235" Thick	0.172" Taick	0.300"\$		-				
	3	Speed	1,725	*	1,500-	Up to 10,000	1,725	1,500-	Up to 10,000		-	•		:	
	festing Machine	Kind of Test	Plate Bending		Axtal	Rotating Bending	Plate Bending	Axial	Rotating Bending	Bending	*		t 2 1 1		
	ē	fype	Krouse	8	*	R.R. Moore	Krouse		R.R. Moore	Rotating Beam	Ŧ	Axial	ŧ	E	
Magnesium Alloys (Continued)		Life, Cycles	Τοτ	*	*		n	*	5	24.108	=	108	•	\$	
loys (O	Patigue Properties	Bt. Dev.	•	ł	1	;	ł	ŧ	ł	•	•	ł	•	1	
ton All	F. 85	E S	12.0	10.0	14.0	20.0	10.0	12.0	8.0	9.5	7.5	13.2	5.5 7 500 F	4.2 650°F	
, degree	Pact	8 23	<u>Q</u>	2		æ	2	•	ŧ	<u>S</u>	E	13.2	5.5 500 F	4.2 650°F	
		ŭ	1.0			*	*		=	1.0	5.6	1.0	=	2	
Table XII.		ption	Plate Bending	Plate Bending	Axial Loading	Rotating Bending	Plate Bending	Axial Loading	Rotating Bending	Smooth	Notched	Rocm Temperature	500°F Tests	650°F Tests	
		Description	F8-16 (AZ-31A-0) Kg. Alloy	J-1 (AZG1A-F) 1G- Alloy	£.	2	0-1 (AZBOA-F) Mg. Alloy	t	t	AZB1-T4. Cast Megnesium Alloy	t	HM-31 (Thorium- Manganese) Forged Mg. Alloy	ŧ	g	
		Net.	19	2	*		*	2	t	99	ŧ	89	8	*	
		1	55	%	73	82	59	8	છ	88	છ	đ	જ	8	
WADD	TR	60-						110)						

	Best Trestment	Stress Relieved 500°F, 15 min., AC.	750°F, 2 hrs., AG; Stress Relieved 600°F, 15 min., AG.	. 8	•	5	*	E						
Table XII. Magnesium Alloys (Continued)	Chemical Composition	As specified by ASM.	8		E		E	e .						
Table	Hard.	DPH 58 2.5 kg	i	;	•	:	!	•	ļ					
	108 R.A. \$	5.4 4	17.7	r	2	18.3		ŧ	\	•	ł	\$ \$ 1		
	Static Properties YP Elong. R. ksi \$ \$	3.4	20.0	E	2	18.1	E	E	- -	•	16.2	25.7 500 F	•	
	Static YP ksi	4.22	28.6	t		31.2	2	2	ឧ	=	41.7	20.3 500 F	1 1	
	UTS	36.8	6.44	ŧ	=	म -8ग	*	ŧ	乾	E	6.94	20.0 500 *	•	
	Item	25	95	57	æ	65	8	19	88	63	3	ક	%	

		•		.,							
	daen	Printer							į		
	Boodse	8150		1		•		•		•	
	9	Speed		1			•	•			
	Testing Machine	Kind of Test		•			•	•	•	***	
		eggi.	Axtal			Actal	•			•	
Table XII. Magnesium Alloys (Continued)		Life, Cyeles	308	*		7ot	*	E	8	2	
loys (Co	Fatigue Properties	g.	i	i	•	•	į	ł	į	•	
TV W	se Pro	8 <u>2</u>	8.5	3.5	2.5	10.2	6.2 500 °F	7.0	4.5 650°F	6.0	
(Trees)	Fatig	S _m ks1	8.5	3.5	2.5	10.2	6.2 6.2 500°F 500°F	9	4.5 4.5 650°F 650°F	3 60	·
П. 1		¥	1.0	=	•	1.0 1					
Teble X		ption	Room Temperatume	500'F Tests	600'F Tests	Rock Temperature	500'F Tests	ŧ	650'F Tests		
		Description	HK-31 (Thorium- Zirconium) Ammealed Mg. Alloy		=	Me-21 (Thorlus- Menganese) Forged Mg. Alloy	•	•	•	•	
!		ż	\$			6		*	•	*	
		Į,	67	88	\$	٤	R	ध्य	ھ	*	
WADD	TI	₹ 60-	42					112			

	Heat Treatment	8 8 8 8 8	ŧ • •		4 2 6 5 6 9		***			
. Megnesium Alloys (Continued)	Chemical Composition				1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	4 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0		1 1 0 0		
Teble XII.	Bard.		1	•		1	1	i		
	ites B.A.		ł	!	ŀ	!	ł	i	į	
	Static Properties YP Elong. R., kei \$ \$	21.0	18.0	ļ		ł	i	į	1	
	Statio Est	1	500	ì	•	i	į	l	ł	
	88 FE	3.0 3.0	16.0 500°¥	;	•		ŧ	į	ŧ	
	8 21	67	8	8	٤	r.	22	73	*	

	Spectures	Parface Pinich			,				0.300"\$ Ground	8	Mech. & Polish		Stretch & Oroma	Oround &	Oroma	
	8	Sise	0.275°¢	0.225°			0.275"	0.225"¢ root	0.300"			E	3	8		
	2	Speed	1,800	8			30,000	*						1		
	Testing Machine	Kind of Test	Roteting Bending		•	*	=	8	Rotating Bending	•	t	•		•	E	
		Type				1 1		1	•		•		† † †	•		
24		Life, Cycles	701			t .			2×107		8	t	*		2	
LIA ALL	Patigue Properties	9t.	i	į	ļ	i	ł	•	ł	ł	!	!	i	1	:	
Titen	Fe Pr	Ke 1	55	31	8	52	43.6	38	63 to 70	ส	88	2	な	26	29	
ij	Pati	Se in	욡		=			ŧ	<u>6</u>	E	r		t	=	2	
Teble XIII. Titenium Alloys		3	1.0	1.78	2.50	3.48	1.0	2.50	1.0	2.7	1.0	2.7	1.0	1.0	1.0	
		Description	Smooth	60° V-notch, R = 0.010"	Beni-circ. notch, R = 0.025"	60° V-notch, R = 0.005"	Smooth	Semi-cire. notch, R = 0.025"	Smooth	60° V-notch, R - 0.010"	Smooth	60° V-notch, R = 0.010"	Smooth	T.	Smooth	
		Ā	Ross Type Ti-Alloy.	•	ŧ	*		ŧ	£1-150A	2	8	r	8	r	RC-130B	
		Bef.	u	8	2		=	g	72	2	r	2		Ŀ		-
		Item	ı	O)	m	*	~	9	7	80	٥,	ន	я	검	ध	

		Heat Treatment		1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1					8 8 8 8	1 1 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2 2	1	1	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	Anneal 1300°F, AC.	
I. Titenium Alloys (Continued)		Chemical Composition	c-0.156, #-0.040	ε		3	C-0.188, N-0.045	•	Cr-2.6, Fe-1.3, O ₂ -0.2	E	Ξ	t	Ε	r	Ma-4.0, Al-4.0	
reble xxx	Bard. Bard. 17-20 17-20 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1															
		B.A.	;	į	i	i	i	i	ł	:	}	ł	ł		;	
	Static Properties	Elóng.		į	į	ł	ł	ł	19.5 to 24.5	2	22		=	t	ដន្តដ	
	Static	Ka th		*	*		ŧ	2	122 140.8	=	=	*	=	2	140.9 to 154.4	
		trest	į	•	;	;	!	;	137.3 to 155		*		ŧ	ŧ	151.5 to 159.2	
		Item	М	N	8	4	'n	9	7	80	٥	엵	я	ឌ	13	
WADD	TR	60-4	2					11	5							

	•	11	j		2 4	₩,					İ		La	•	•	
	pools	filee	0.300%	6.3000°6 0.2500°6	0.25 0*6			0.250°6	0.300%			•	0.290"6			
	2	Speed	•	10,000	1,800	*	10,000	6,000	8				6,000	*		
	Testing Machine	Kind of feet	Boteting Bending	Roteting Bending	Botating Bending		•	Roteting Bending		•	•	*	Botating Bending		•	
	ñ	fype	i	R.R. Moore	R.R. Moore	1	2	R.R. Moore	*	*	8	*	R.R. Moore	•	2	
Titemium Alloys (Continued)	•	Life, Cycles	2×107	207	7 01	*		7ot	*		8	•	2οτ			
1078 (Patigue Properties	St.	ł	3.5	i	į	•	i	t t	į	i	•	i	i		
ntue A	F2 62	R S	₹	306	#. **	##	154	ğ	454	78	18	17±	\$	#16	\$16	
11.	Pati	Red Lea	<u></u>	2	2	*		욡			*		2			
Teble XIII.		3	2.7	1.0	1.0	*	2	3.0	4:1	8.8	3.8		1.0	*	*	
Table		Description	60° V-notch R = 0.010"	Separground Finish"	Basoth	8	•	Rolled 60° V-notch R = 0.010"	Machined Radius Motch R = 3/32"	Machined Square Notch Fillet R = 0.010"	Machined 60° V-notch, R = 0.010"	Dismond Ground 60° V- notch, R = 0.010"	Smooth	•	±	
			RC-130B	Re-130B	£1-75A	2		TH-75A	8	2	t	2	RC-130B	*	z	
		Bef.	22	73	ąL			75	2	2	Ł	2	42	*	2	
		Item	ភ	15	97	17	87	19	8	ส	81	23	45	80	8	
WADD	TR	60-	42					1	16							

	Beat Treatment	Annewl 1300°F, AC.		Annealed 1450°F in Argon.	2	•	2	ı	2	•	E	Annealed 1450°F in Argon.	=	•	
[. Titenium Alloys (Continued)	Chemical Composition	Mn-4.0, Al-4.0		C-0.025, H-0.061, Fe-0.19	C-0.04/0.07, H-0.10, Fe-0.20, H-0.01, H-0.02/0.05, 0-0.20	•		2	t	ŧ	2	C-0.1, H-0.03, Na-5.9, A1-5.0	C-0.1, H-0.02, Mn-4.4, Al-4.1	C-0.1, N-0.08, Nn-3.9, A1-3.9	
Pable XIII.	Eard.	ı	-	ļ	1	:		:	!	:		•	!	i	 .
	8.A.		•	50.9	3	ŧ	*	=	*	2	E	2-भा	43.1	47.0	
	Static Properties YP Elong. kei \$	ដនដ	13.9	85.50 2.50	27.3	=		*		*	t	17.0	25.0	18.0	
	Static TP kai	160.9 154.4	153.9	Prop.	P.L. 47.9			•			*	P.L. 124.8	P.L. 82.2	119.0	
	11 E	151.5 to 159.2	163.3	8.5	g 4. 3					t	t	157.7	149.2	160.0	
	8	#	જ	91	11	87	13	8	ส	83	ଷ	ŧ	83	%	

					پيپنين										
	Specimen	Pinish				•		: :	6 6 8	# ! !			1 1 1	ŧ •	
	6	Bise	0.300"	•	•	0.250"	0.150"	0.300"\$	0.250"		0.250"	0.250"	0.300"\$	8	8
	artre	Speed	6,000	8		8	*		*	8	6,000	9,000	ŧ	8	8
	Testing Machine	Kind of Test	Rotating Bending		*		*	•	x	t	Rotating Bending	Rotating Bending			
	<u></u>	Type	R.R. Moore	*	8		8	*	2	8	R.R. Moore	R.R. Moore		*	
Titenium Alloys (Continued)		Life, Cycles	107	*	E	8	E	8	2		107	107	8	*	8
10ye (Fatigue Properties	st. Dev.	•	i	•		į	}	į	•	ļ	;	;	:	i
tive Al	the Pro	Se kei	\$	53‡	38‡	87±	***	37±	Ŕ	13‡	\$	*	ij	24	ğ
Tite	Fatig	S _m ksi	2		.			ŧ			유	0		*	•
Teble XIII.		Kt	4.1	8 .	3.2	3.0	2.4	3.8	2.5	3.0	1.0	3.0	% &	8	3.8
Teble		Description	Machined Redius Motch R = 3/32"	Machined Square Notch Fillst R = 0.010"	Machined 60° V-notch R = 0.010"	Rolled 60° V-notch R = 0.010"	Very Heavily Rolled V-notch, R = 0.010"	Machined 60° V-notch R = 0.010"	Commercially Ground Square Notch. Fillst R = 0.010"	Comercially Ground 60° Y-notch, R = 0.010"	Smooth	RC-A-30314 Rolled 60° V-notch R = 0.010"	Machined Square Notch Fillst R = 0.010"	Machined 60° V-notch R = 0.010"	Diemond Ground 60° V- notch, R = 0.010"
			RC-130B			•	•		2		RC-A-30314	RC-A-30314	*	8	ž.
		Ref.	75			•		=	t		47	75	:	:	
I		Item	12	88	&	8	æ	<u></u>	33	₹E	35	36	37	8	39

	Heat Trestment	Annealed 1950°F in Argon.	•	•	.nogra at 9°02At betseana	•	•	•	•	Annealed 1450°F in Argon.	•	*	*	•
I. Titanium Alloys (Continued)	Chamical Composition	C-0.1, H-0.08, Mb-3.9, A1-3.9	=	•	C-0.1, H-0.0t, Mn-k.k, Al-3.9	ŧ	•	F	n n	C-0.1, N-0.05, Sp-2.58, Al-4.13	•	ŧ		=
Table XIII.	Bard.	ļ	i	:	ţ	ļ	ļ	;		1	ŀ	i	i	ŀ
	ites R.A.	47.0	2	#	16.0	•	:	8	E	40.0	ŧ	ŧ	r	
	Static Properties YP Elong. R	18.0			18.7	=	=		z	16.0		=	E	E
	Stati TP Est	119.0	*	=	P.I. 138			=	#	P.L. 124	*	=	E	2
	UTS E E E	160.0	ŧ	2	148	•	=	F		138	E		*	=
	I LE	23	88	83	8	31	85	33	₹	35	36	37	8	39

			_				_		_							
	es dentes	Plate.		•			•	Rend Polits	:	Hend Politeh	•	Rend Polish	\$ 8 8	Read Politeh	1 6 1	Rend Polish
	3	Aise	0.250"	i	1	•		0.150"			*	8		2	8	=
	120	Operat cya	6,000	1,800 or 10,000	8	1,800	10,000	8,000- 10,000	8			*	t	2	8	8
	Posting Machine	Kind of Seet	Botating Bending	Roteting Bending	8	*		Rotating Centil.	•		•		*	*		
		fype	R.R. Moore	R.R. Moore	;	3	8	Krouse		*	•		•			*
Titenium Alloys (Continued)		Life, Cycles	107	10 7	8	8		701	8	E	8	8		8	8	*
10ys (0	Patigue Properties	æ.	•	i	•	i	•	i	i	i	į	į	i	į	ł	•
A mar	1 and 1 and	Be kei	184	봈	#	55±	5 0	52.7	21.7	51.2	27.7	53.₺	28.0	66.5	33.0	57.2
Tite	Patt	B _a kei	2	2				2		=	E	*	E	E	=	
H.		ä	2.5	1.0		*	2	1.0	3.0	1.0	3.0	1.0	3.0	1.0	3.0	1.0
Toble XIII.		aoj	f Ground Square et R = 0.010"	Lent		49		Smooth	Notch 0.037" Deep, R-0.005"	Smooth	Motch 0.037" Deep, R-0.005"	Smooth	Motch 0.037" Desp, R=0.005"	Smooth	Motch 0.037" Deep, R-0.005"	Smooth
		Description	Commercially Ground Notch. Fillet R = 0.	Without Coolent	•	With Coolent	ŧ	Grain Size 0.008± mm		Grein Sise 0.024 mm	*	Grain Sise 0.12# mm	E	7.5		Grain Size 0.008t am
			RC-A-3031A	£1-75A	=		*	Commercial Titenium	*	*	*	#	2	#1-7.5 Cr-7.5 No Alloy	*	E.
		Bef.	73	92	*	*	2	ш	2	*	*		*	2	ŧ	2
		Item	04	14	3	£3	\$	54	2	24	83	64	20	13	×	53
WAD	D T	'R 60	-42			—			120					-	_ 	

		Heat Trestment	Annealed 1450°F in Argon.		1	•		Anneal 1290°F, 2 hrs. in Air.	ŧ	Anneal 1605°F, 16 hrs. in Argon.	E	Ameal 1650°F, 1 hr. in Argon.	•	Anneal 1290°F, 1 hr. in Air.	*	Anneel 1830°F, & hrs. in Argon.
. Titemium Alloys (Continued)		Chemical Composition	C-0.1, N-0.05, Sn-2.58, Al-4.13	c-0.025, H-0.061, Pe-0.19	•	•		H-0.014, C-0.03, Fe-0.29, 0-0.10, H-31 ppm	*	•	•			Cr-7.60, No-6.66, N-0.026, C-0.03, Pe-0.32, O-0.13, H-44 yrm.	*	
Teble XIII.		Bard.		RC 23-24	8		*		į	i	i	1	i	•	i	
	sies	R.A.	0°0†	54.6	£	ŧ	t	\$	r	\$	2	=		Ş	*	55#
	Static Properties	Klong.	16.0		į	1 2 1	ł	# \$	E	#O#	E	£		# #	E	=
	Stat1	K K	P.L. 124	જ જું		2	E	0.0 19.0	*	#8 #	£	±		‡\$ZT		=
		UTS	338	%	.	E	8	₫	*	*	\$	ŧ	E	47		141
		Item	գ	14	24	£ 1	3	45	94	24	83	64	ይ	51	22	53
W	ADD	TR 60	0-42					121								

MAD				Table XIII.	HI.	Tita	of une Al) skott	Titenium Alloys (Continued)					
						Fati	Sue Pro	Fatigue Properties			Testing Machine	hine	Spec	Specimen
Ite	Bef.		Description	g	ኧ	S _m ks1	3e 17.1	St. Dev.	Life, Cycles	Type	Kind of Test	Speed	Size	Surface Finish
ホ	ш	T1-7.5 Cr- 0 7.5 No Alloy 0	Grain Size 0.008t mm	Motch 0.037" Deep,R-0.005"	3.0	윤	32.6	1	107	Krouse	Rotating Cantil.	8,000-	0.150"	
55		T1-2.5 Cr- Grain 31: 2.5 No Alloy0.0024 mm	Grain Size Smooth	Smooth	1.0	=	18.2	1	2	2	E	s	8	Hand Polish
<u>%</u>	ŧ	t	£	Motch 0.037" Deep,R-0.005"	3.0	=	31.5	į	*	:	r	:	\$!
57	±	5 0	Grain Size 0.004± mm	Smooth	7.0	=	49.1	;	t	z .	I	E	ŧ	Hend Polish
% ———	t .	t	F	Notch 0.037" Deep,R-0.005"	3.0	=	27.8	ł	E	r	E	g	t	
23	*	50	Grain Size 0.20 mm	Smooth	1.0	E	55	}	=	t	t	E	E	Hend Polish
8	ŧ	.	=	Notch 0.037" Deep,R-0.005"	3.0	:	27.2	;	=	£	E	*	5	
6	£		Grain Size 0.40 mm	Smooth	7.0	E	9	:	E	=	E	=	*	Hend Polish
8	E	ı	E	Notch 0.037" Deep,R=0.005"	3.0	=	28.2	;	5	E	r	E	F	
63	78	6 Al-4 Va Titanium Alloy	Þ	Smooth	1.0	No	83#	1	107	R.R. Moore	Rotating Bending	10,000		Hand Polish
ঠ	=	E		#	1.0	=	36	•	#		T	E.		2
65	29	6 Al-4 Va Titenium Alloy	Æ	Smooth	1.0	No	83.6	5.4	5(107)	R.R. Moore	Rotating Bending	12,000	0.230"\$	
8	38	6 Al-4 V Titenium Alloy Ber	min		1.0	61	61		106	-	Axiel		-	

WADD TR 60-42

		Heat Trestment	Ameal 1830°F, 4 hrs. in Argon.	1380°F, 1 hr., FC to 1200°F, AG.	E	1380°F, 64 hrs., FC to 1200°F, AC.	F	1650°F, 30 min., FC to 1380°F, hold 1 hr., FC to 1200°F, AC.	r	1830°F, 1 hr., FC to 1380°F, hold 1 hr., FC to 1200°F, AC.	ŧ	1300°F, 2 hrs.	1750°F, 1 hr., WQ; 1100°F, 2 hrs.	Not reported - heat treated by vendor.	
I. Titenium Alloys (Continued)		Chemical Composition	Cr-7.60, Mo-6.66, N-0.026, C-0.03, Pe-0.32, O-0.13, N-44 ppm.	Cr-2.32, No-2.58, N-0.015, C-0.04, Pe-0.27, O-0.13, H-60 ppm	E	ŧ			E	t	•	A1-6.09, V-4.06, Fe-0.147, N2-0.013, C-0.015, H2-0.004	-	Al-5.5, V-3.9, H-0.01, C < 0.10	
Table XIII.		Hard.			i	1	;		i		i	i	•	RC 34	l
	ties	B.A.	55±	1 00	=	58±	=	1 84	ŧ	38	t		ł	39	
	Static Properties	Elong.	\$\$	324	E	284	ŧ	564	E	r	E	1	;	15	
	Stati	Ke 1	125±	95‡	=	\$		\$	=	r	±		•	138	
		orrs ket	141	109		305	E	106	r	108	E	242	167	145	160
		Item	t	55	56	57	X.	29	8	62	88	છ	₫	65	%

	_	-			_							-	_		_		_	
	1	Pirite.	Polished with Coolean			•		•		*			•	•	E	t		
	Brecin	Sise	0.19*6			3	0.230"		=	-	.	*	*		E	x	ε	
	shine	Speed	3,600			8	8	2	*		E	E	#	£	*	*	E	
	Testing Machine	Kind of Test	Axial	•	2	=	•		*	=	=	=	=	2	£	E	r	
		Type		•	-		****				# # # #	!						
Titenium Alloys (Continued)		Lift, Cycles	2.16(10 ⁷) (100 hrs)	E	£	*			8	2	E	E		8	\$	#	ħ	
lloys (Patigue Properties	B.	1	ł	į	1	ł	;	;	;	1	į	:	•	•	:		
ntum A	gue Pr	S. S. S. S. S. S. S. S. S. S. S. S. S. S	\$	太	43 ±	\$\$ \$\$	₩	61 ‡	38	ξ	\$	#2#	37±	26 ±	33‡	37±	Slut	
Tite	Pati	S. Its	0	ま	₫	0	0	0	59	0	o	ğ	55	0	33	55	0	
XIII.		컱	1.0	*	ŧ	=	t	:	E		F	E	ŧ	=		2	Ŀ	
Table XIII.		ion	75°F Tests.	E	*	u	400°F Tests.	600°F Tests.	#		800°F Tests.	*	#	=	*		1000°F Tests.	
		Description	7 Al-3 No Titenium Alloy, Aged	E	E	7Al-3 No Fitanium Alloy, Ammealed	7Al-3 Wo Titenium Alloy, Aged	E	E	7Al- 3% Titanium Alloy, Amealed	7Al-3 Mo Titanium Alloy, Aged	t	±	7Al-3 Mo fitenium Alloy, Annealed	ŧ	5	7Al-3 Mo Titanium Alloy, Aged	
		Ref.	62		ŧ	:	2	,	£	*	2	ŧ	2	E	£	F	£	
		Item	19	8	89	70	и	72	73	42	75	76	77	78	79	8	81	
WADD	TR	60-4	2						124									

		Heat Treatment	1560°F in Argon, 30 min., AG; 1020°F, 24 hrs., AG.	•		1450°F in Argon, 1 hr.; Cool to 1050°F (100°F p. hr. max.).	1560°F in Argon, 30 min., AC; 1020°F, 24 hrs., AC.	•	*	1450°F in Argon, 1 hr.; Cool to 1050°F (100°F p. hr. max.).	1560°F in Argon, 30 min., AC; 1020°F, 24 hrs., AC.	*	•	1450°F in Argon, 1 hr.; Cool to 1050°F (100°F p. hr. mex.).	2	8	1560°F in Argon, 30 min., AC;
Titenium Alloys (Continued)		Chemical Composition		•				9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9			4 9 8 9 1 1 1		771111111111111111111111111111111111111	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	\$ 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9		89 88 88
Teble XIII.		R.A. Bard.		:				:					•		8 8	•	
	Static Properties	Elong.	ţ	i	•	•	i	ł		8 8		:	ł		† 1	!	•
	8 48	UTS TP kei kei				***	8 8	:				•	!			!	
		17.	19	8	\$	70	п	ध्र	73	42	73	92	ш	87	62	8	81

		Serfee Field	Polished, with Coolean		s		8	
	Brects	Size	0.230	•	*		8	
	hine	Speed	3,600	=	2	*	*	
	Testing Machine	Kind of Test	Axfal	#	8		*	
		Type					-	
Titenium Alloys (Continued)	•	idfe, Cycles	2.16(10 ⁷) (100 hrs.)	*	E	=	8	
Lloys (Patigue Properties	St. Dev.	i	•	i	ł	;	
oton A	gue Pr	Red Ket	क्र	29±	£1,5	33*	5/2	
Tite	Pati	Ret Ket	ಜ	43	0	33	14	
Hi.		ጟ	1.0		2	:	*	
Table XIII.		ption	1000°F Tests.	ŧ		:	E	
		Description	7Al-3 No Titenium Alloy, Aged	2	7Al-3 Mo Titenium Alloy, Annealed	t	2	
		Ref.	79	3		*	:	
		Item	88	83	ಪೆ	ቈ	8	
WA	DD	TR 6	0-42					126

	Heat Freshment	1560°F in Argon, 30 min., AC; 1020°F, 24 hrs., AC.	8	1450°F in Argen, 1 hr.; Ocel to 1050°F (100°F p. hr. max.).	8	8	
fitanium Alloys (Continued)	Chemical Composition				# 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1		
Teble XIII.	Hard.	1		:	i		
·	S.A.	!	ł	i	i	:	
	Static Properties YP Elong. 1 kei \$		•	i	ţ		
	Stati YP Kei	1	ł	i	ł	ŧ	
	UTES	1	ŧ	1	ŀ	•	
	Ites	88	83	đ	86	98	
WAD	D TR 60	-42			· · · · · · · · · · · · · · · · · · ·		127

	=	Surface Finish	%	2			3-5 micro- in.			•			1 1 1		
	Specimen	815.6	0.25	2	0.58"±	0.58" \$	0.300"\$	2	1/2" x 0.233"	1/2" x 0.223"	E	1/2" x 0.246"	.	1/2" x 0.261"	
	A	Speed	3,600	*	1,500	8	12,000	t	%	E	t	•	E	E.	
	Testing Machine	Kind of Test	Roteting Bending	Ł	Rotating Cantil.	E	Rotating Bending	E	Push- Pull	E	=	2	r	2	
	Tes	Type	R.R. Moore	=	•		R.R. Moore	и) 	! ! !	: : :	1		
Miscellaneous Materials	_	Life, Cycles	107	#	2(107)	*	5(107)	E	107	£	r	\$:	#	
smoeur	perties	St. Dev.	:	:	i	;	4.5	2.7	•	!	: :	ļ	ŀ		
iscell	Patigue Properties	Se ksi	34.0	23.0	9.5	9.5	8 1	36.5	10.4	10.4	7.6	0.11	8.7	10.9	
1 1	Fatig	S _E	SE SE	2	<u>S</u>	=	£		r	r	=	r	2	E	
Table XIV.		Kŧ	1.0	=	1.0	3.9	1.0	=	1.0	1.0	3.5	1.0	3.5	1.0	
#1		ption			Smooth	60° V-notch R = 0.010"	Smooth	Smooth	rced Smooth	Smooth	1/8"ø Hole.	Smooth	1/8"ø Hole.	Smooth	
		Description	Ingot Iron	£	Grey Iron	ŧ	Al-Ni-Bronze	Beryllium Copper	Glass-Fiber-Reinforced Plastic Laminate 73*F,50% Rel.Humidity, 0 to Warp.	t	ŧ	r	E	=	
		Ref.	80	ε	#	*	80	=	8	E	2	ŧ	8	*	
		Item	7	Q	3	.	5	9	2	90	9	23	я	껅	
WADD '	TR	60-42	5					128							

2		Heat, or Other, Trestment	Tested as received, hot rolled.	1400°F, 1 hr., W.Q.	Tested as cast.	2	By vendor.	By wendor. Also, age-hardened 600°F, 3 hrs., AC.	14 pe1, 220°-250°F, 90 min.	E	Ε	£	ŧ	.	
Table XIV. Miscellaneous Materials (Continued)		Chemical, or Other, Composition	C-0.012, 18n-0.017, P-0.005, S-0.025	•	с-3.65, 11 n-0.73, 81-2.46, P-0.265, S-0.132	u	сы-81.75, ип-0.71, ге- 2.86, и1-4.69, A1-9.90	он-97.46, ве-2.08, со-111-0.40	Polyester resin (Paraplex P43), 34.35, reinf. v. "lål glass fabric", 23 plies.	Polyester resin (Paraplex P43), 37.8% reinf. v. "112 glass fabric", 84 plies.	2	Polyester resin (Paraplex P43), 38.6%, reinf. v. "120 glass fabric", 64 plies.	t	Polyester resin (Paraplex P43), 29.5%, reinf. w. "184 glass fabric", 10 plies.	
Table		Hard.	-	77.B 54.	:		Rc 20	Re 37	Barcol 70	B.73	E	B.72	E	B.70	
	ties	R.A.	9.59	66.5	i		261	5.9	i	į	į	i	i	! !	
	Static Properties	Elong.	5. 2.	21.5	i	:	18#	4.3	8 8 8	ŀ	ł	ł	į	ļ	
	Stati	YP ksi	式	33	ì	•	85	641	9.4 Prop. Lim.	11.7 P.L.	=	13.0 P.L.	2	9.8 P.L.	
		UTS kei	6.99	55.1	20.3	ŧ	911	175	52.2	146.3	=	1.5.7	ŧ	50.3	
		Item	٦	۵	3	#	5	9	2	ω	6	9	ជ	ង	
WADD	TR	60-4	2	<u> </u>				129	i						

	Specimen	T. C.		•											
	ž	Sise	1/2" x 0.261"	1/2" x 0.234"		1/2" x 0.247"		1/2" x 0.222"	•	=	E	=		. E	
	9	Speed	8		E	t	=	*	2	=	z	=	£	Ξ	
	Testing Machine	Kind of Test	Push- Pull	•	:	•	=	:	=	£	E	=	z	=	
timed)	¥.	Туре	6 6 6	! !	1 1 1 1	1 1 1 1	1		;	:	•		1	-	
Miscellaneous Materials (Continued)		Life, Cycles	107	E	8	8	r	£	E	t		=		z	
16 Mater	Patigue Properties	St. Dev.	1	i	ł	1		1	!	;	•	;			
laneor	S E	Ke 1	8.6	3.5	4.5	16.1	14.2	10.3	5.0	4.9	8.0	3.5	1.5	6.4	
Macel	Peti	Ket Hat	<u>o</u>	E	=	E	E	2	9.5	23.0	No No	7.0	17.6	No	
		K	3.5	1.0	3.5	1.0	3.5	1.0	=	=	3.5	=	2	1.0	
Table XIV.			1/8"\$ Hole.	Smooth	1/8"\$ Hole.	Smooth	1/8"ø Hole.	Smooth	=	:	1/8"¢ Role.	=	=	Smooth	
		Description	Glass-Fiber-Reinforced Plastic Leminate 73°F, 50% Rel.Humidity, 0° to Warp	F	r	E	Ē	Heat Resistant Glass- Fiber-Reinf. Plastic Laminate, 73°F',50% Rel. Humidity, 0° to Warp	=	=	=	Ε	=	Heat Resistant Glass- Fiber-Reinf. Plastic Laminate, 73°F,50% Rel. Humidity, 45° to Warp.	
		Ref.	8	2	E	-	Σ	z.	E	ε	E	:	=	=	
	Γ	Item	ដ	#1	15	97	17	ध्य	19	8	ผ	8	23	† ∂	
WAD	o T	r 60	-42					130							

	Heat, or Other, Prestment		14 pe1, 220°-250°F, 90 min.	•	•	0 ps1, 212°F, 10 min.; 50 ps1, 212°F, 25 min.; 0 ps1, 400°F, 120 min.	•	14 ps1, 220°F, 45 min.; 0 ps1, 500°F, 180 min.	=	*	ŧ	r	•	e.	
Table XIV. Miscellaneous Materials (Continued)	Chamball on Other Commonstition	commican, or other, composition	Polyester resin (Paraplex P43), 29.5%, reinf. w. "184 glass fabric", 10 plies	Polyester resin (Paraplex P43), 58.3% reinf. w. "glass mat", 7 plies	ŧ	Epoxide resin (Epon 828-14% CL), 37.7%, reinf. w. "181 glass fabric", 24 plies	T.	Polyester resin (PDL 7-669), 35.3%, reinf. w. "181 glass fabric", 23 plies	=	\$		=	•	u	
Table	Ţ	Harra.	B.70	B.59	=	B.71	E	B.74	2	£	t	=	r	и	
	ties	. A.		;))	; !	}	1	ì	ł	;	!	!		
	Static Properties	grong.	ŀ	į	;	ļ	;	ļ	ļ	į	;	;	i	,	
	Static	rr ksi	9.8 P.L.	5.2 P.L.	=	27.8 P.L.	=	18.0 P.L.	E	=	₹i	=	z	=	
	İ	VES kei	50.3	०.ध	=	49.0	=	146.2	=	=	E	E	ŧ	=	
	i	I C	13	#	25	93	7.7	क्ष	13	8	72	83	દર	₹.	

WADD				Table XIV.		Misce	Llaneou	s Mater	Miscellaneous Materials (Continued)	timed)				
TR 60-	Item	Ref.	Description		Řŧ	Fet: Sn ksi	igue Pr Se ksi	Fatigue Properties Sm Se St. si ksi Dev.	is Life, Cycles	Ter	Testing Machine Kind of Test	se Speed cpm	Spec Sire	Specimen ze Surface Finish
42	જ	8	Heat Resistant Glass- Fiber-Reinf. Plastic Laminate, 73°F,50% Rel. Humidity, 0°to Warp.	Smooth	1.0	No.	10.9	1	107	1 1 2 1	Push- Pull	86	1/2" x 0.221"	
	%	E	£	1/8" ¢ Hole.	3.5		7.01	i	=	:	=	s	5	: :
······································	23	ŧ	E	Smooth	1.0	=	5-टा	i	z	i	t	E	1/2" x 0.257"	
	R			1/8"ø Hole.	3.5	=	10.0	;	=		=	E	E	* • •
1	83	:	F	Smooth	1.0	=	7.9	; ;	=		E	*	1/2" x 0.261"	:
.32	30	s	=	1/8"ø Hole.	3.5	=	6.9	•	=	•	:	E	E	
	31	टम्	Glass Fabric Laminate Plastic, O° to Warp, Room Temp.	Smooth	1.0	Мо	10.5	•	2x10 ⁷		Rotating Cent.		0.275"\$	•
	×	81	Yellow Birch Smo	Smooth	1.0	No	0.4		108	R.R. Moore	Rotating Bending	3,450	0.330"	No. 00 Emery
	33	±	Hard Maple Natural		:	2	6.2	į	=	ŧ	z.	:	£	=
	ŧ	r .	Yellow Birch Leminated	_	2	=	ग.प	• •	<u> </u>	=	E	10,600	£	
	35	r	.09 	60° V-notch R = 0.010"	2.8	r	7.6	i	E	=	£	£	E	=
	36	=	Hard Maple Smo Leminated	Smooth	1.0	=	10.0	; •	:	=	E	3,450	E	:

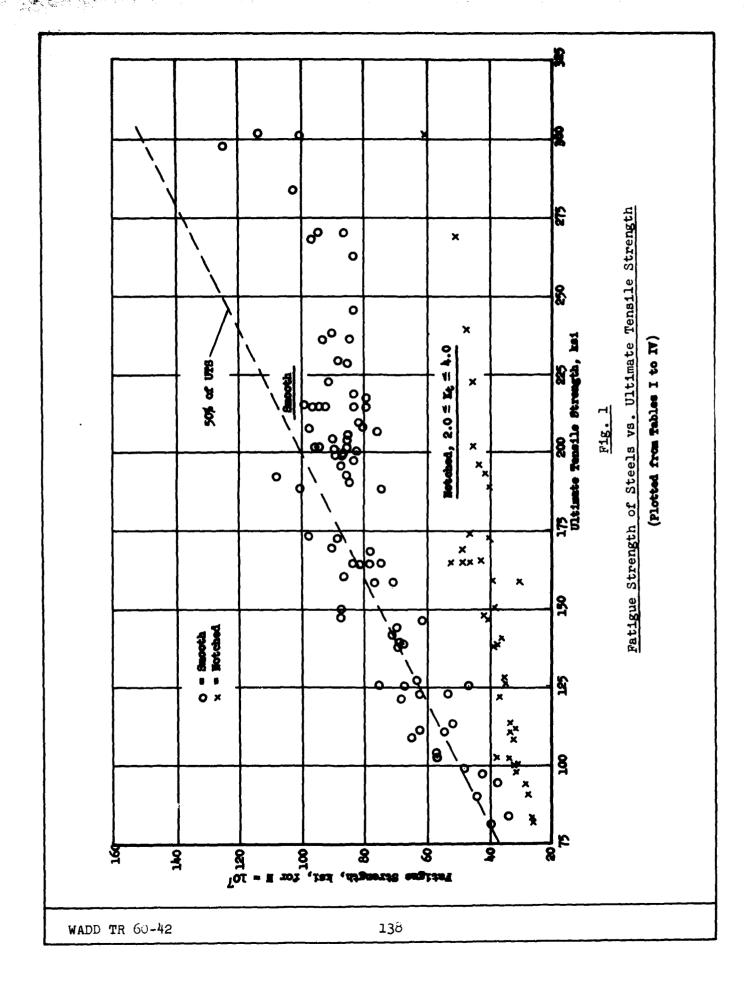
	Heat, or Other, Trestment	0 pe1, 310°F, 3 min.; 200 pei, 42 min.; 0 pe1, 400°F, 1440 min.	ŧ		•			Pressed at approx. 15 psi into 1 1/4 inch panel.	None. Spec. gravity 0.69.	None. Spec. gravity 0.70.	Compressed 50%; to spec. grav. 1.25.		Compressed 50%, to spec. grav. 1.38. Phenolic resin paper bonding.	
Table XIV. Miscellaneous Materials (Continued)	Chemical, or Other, Composition	Rpoxide resin (Rpon X12100-4/E), 35.0%, reinf. w. "181 glass fabric", 24 plies	E	Phenolic resin (BV17085), 28.0%, reinf. w. "181 glass fabric", plies	=	Silicone resin (DC2106), 31.0%, reinf. w. "181 glass fabric", 28 plies	r.	CIL-91-LB Resin, $181-114$ Fiberglass Fabric	Solid (non-leminated)	=	1/16 inch laminations, Impregnated. Phenolic resin content 35%.	=	1/8-inch leminations. Non-impregnated.	
Table	Hard.	B.74	=	B. 81	E	B.63	,	-	!	1	i i	:	:	
	ties R.A.	i	į	1 9 1	i	!	i	ł	ł	i	į	ł	į	
	Static Properties YP Elong. R., ksi \$ \$	ŀ	ļ	ł	ļ	ł	:	ł	1	•	;	}	;	
!	Static YP ksi	13.8 P.L.	=	12.8 P.L.	=	21.0 P.L.	:	1	ŀ	1 2 1	į	į	:	
	UTS	¹ 12.6	*	6.74	E	37.7	£	O t	Bend. 19.6	Bend. 21.7	Bend.	*	Bend.	
	It em	80	%	23	82	&	8	31	ಜ್ಞ	33	34	35	36	

Continue de la contin	,	-		_						-						
	laen	Surface Finish	No. 00	*		*	*		¥	=	r	t	F	; ; ;	-	
	Specimen	Sise	0.330″€	ŧ	E	ŧ	t .	=	:	=	E	τ	=	9"x1-1/4" x 3/8"	9"x1-1/4" x 5/16"	•
	a e	Speed	3,450	*	2	3,450	10,600	3,450	30,600	3,450	10,600	3,450	10,600	1,790	=	
	Testing Machine	Kind of Test	Rotating Bending	ŧ	r	r	r	:	E	=	E	=	t	Const. Defl.	=	Rotating Bending
ntimed)	T	Type	R.R. Moore	:	:	:	.	*	£	:	:	=	ı.	Krouse	ŧ	
Miscellaneous Materials (Continued)	8.0	Life, Cycles	108	=	5	=	s	2	:	=	=	5	11	5(107)	±	2x107
us Mate	Fatigue Properties	St. Dev.	ł	ł	1	i	}	ł	:	i	ļ	į		•	:	÷
llaneo	fgue P	Se ksi	8.0	o. 4	3.8	10.4	10.0	9.0	4.8	10.9	10.3	9.8	9.0	27% of mod.of	=	33
Misce	Fat	Sm ksi	S.	:	=	=	=	=	=	=	z	:	2	•	1	o N
XIV.		Kŧ	2.8	1.0	2.8	1.0	:	2.8	:	1.0	2	8.8	=		i	1.0
Table XIV.		Description	60° V-notch, R = 0.010"	Smooth	60° V-notch, R = 0.010"	Smooth	=	60° V-notch, R = 0.010"	=	Smooth	t	60° V-notch, R = 0.010"	£	Solid Sitka spruce and Douglas- fir. Approx. 12% moisture content.	Plywoods of Yellow Birch and Yellow Poplar. Approx. 12% moisture content.	ryllium. Room Temperature
			Hard Maple Laminated	=	:	=	=	:	=	=	=	90. 26	ŧ	Solid Sitka g fir. Approx.	Plywoods of Yello Yellow Poplar. A moisture content.	Brush QMV Beryllium.
		Ref.	81	ε	s	E	=	£	E	-	:	=	.	82	:	83
		Item	37	38	39	O 1	141	217	₄ 3	77	145	3	147	8म	64	50
WADI	TI	₹ 60-	42]	134		<u> </u>				

	Heat, or Other, Trestment	Compressed 50%, to spec. grav. 1.38. Phenolic resin paper bonding.	Hon-compressed. Spec. gravity 0.68. Phenolic resin paper bonding.	E	Compressed 50%, to spec. grav. 1.23.	Ξ	Ε	E	Compressed 50%, to spec. grav. 1.31.	t	ī		Tested at 75°F and 65% relative humidity.	n	Mone
XIV. Miscellaneous Materials (Continued)	Chemical, or Other, Composition	1/8-inch laminations. Non-impregnated.	1/8-inch laminations. Non-impregnated.	=	1/8-inch leminations. Impregnated. Phenolic resin content 12%.	£	= .	£	1/8-inch laminations. Impregnated. Phenolic resin content 23%.		r		Clear, straight-grained.	Five 5/16" plies, with thermosetting Phenol-formaldehyde Tego film glue.	Ве-98.6, вео-1.49, ге-0.12, Al-0.037, Mg-0.032, Ki-0.012
Table XIV.	Hard.	ŧ	!	;		i	-	;	!	:	i i	i i	ì	1	:
	ties R.A.	1	ł	i	ļ	ì	i	ŀ	ļ	ì	ł	;	ł	•	•
	Static Properties YP Elong. R. ksi % 9		!	i	;	į	į	i	į	ì	:	į		1	1
	Static YP kei	i	į	;	ł	į	ŀ	ŀ	ļ	;	ļ	i	1	ŀ	36.4 0.2%
	UTS ka1	Bend.	Bend. 19.0	F	Bend.	±	=	.	=	*	=	=	ł	•	£-0 4 1
	Item	37	82	39	2	141	갩	£4	∄	45	9	£ 1 7	84	64	50
WAI	DD TR 6	0-42						135							

	Specimen	Surface Finish			!	1			-	† † †	1	•	:	! ! !		
	Spec	Size	1 6 1 6	-	1	 	!	1 1 1	1	 		!	1	1 1 1 1	•	
	Ine	Speed	1 1 1	\$ 6 8	•	1	1	1 1	1			1		# 		
	Testing Machine	Kind of Test	Axial	τ	t	=	=	r	t	=	=	£	£	=	=	:
ntimed)	ī	Type	8 8 8			1	1	1		! ! !	1	-	1	1	****	
Miscellaneous Materials (Continued)	68	Life, Cycles	2000 hours	107	=	:	E	=	2	5x105	101	:	=	=	E '	
s Mate	Fatigue Properties	St. Dev.	-	1	!	1	ļ	į	į	:	1	ł	:	1	:	ļ
laneou	gue Pr	Se ks1	0	15‡	10#	22	17±	10.5	9	97	9/	3.5±	3.5±	5 #	5 ±	
Miscel	Fati	Sm kei	4.5±	52 1	16±	33±	26±	No	=	2	=	5.5±	5.5±	1 1	4 _	
		K _t	0.0	=	٠-	0.4	~	٥٠٦	٠,	о. -	~	1.0	~	0.1	٠.	
Table XIV.			Stress- Rupture 1100°F	Room Temperature	ŧ	8	E	1100°F	=	=	:	=	=	E	E	
		Description	Hot Pressed, Hot Extruded	Hot Pressed	=	Hot Pressed, Hot Extruded	=	Hot Pressed	F	Hot Pressed,	=	Hot Pressed	=	Hot Pressed, Hot Extruded	=	
			Brush QMV Beryllium	Ξ	=	F	=	2	=	±	E	z	=	22	£	
		Ref.	1 8	85	2	=	.	ŧ	Ε	-	E	E	:	=	.	7
		Item	15	52	53	75	55	96	57	28	59	8	19	8	63	1
WADD	TR	60-4	1 2						136	5						

	Heat, or Other, Treatment		•	1 1 1 1 1	•	!			† 1 1	1			:		
7. Miscellaneous Materials (Continued)	Chemical, or Other, Composition		•				1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1				3 2 2 3 4	***************************************			
Table XIV.	Hard.			;	<u> </u>	1	!	1	:	!	;	!	i		
	ies R.A.	:	•	ļ	ì	ŀ	1	•	ł	1	;	:	ł	1	
	Static Properties YP Elong. R ksi \$ \$	i		i	•	ļ	1	f 1	•	1	•	f	į	***	
	Static YP ksi	1	ł	i	!	ì	i	ì	;	į	ļ	ŀ	ŧ ! !	;	
	UTS Ket	:	i	i	1 1	i	!	į	1	1	ì	i	i	•	
	Item	51	25	53	去	55	26	57	8%	59	9	79	8	63	



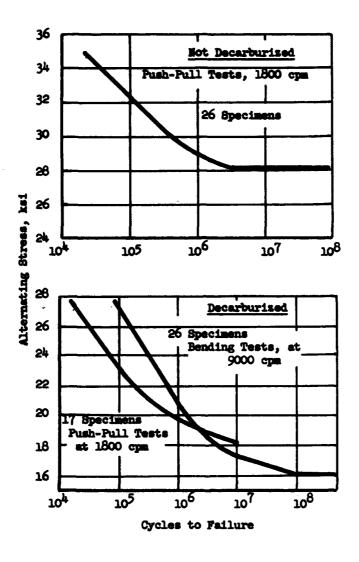
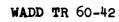
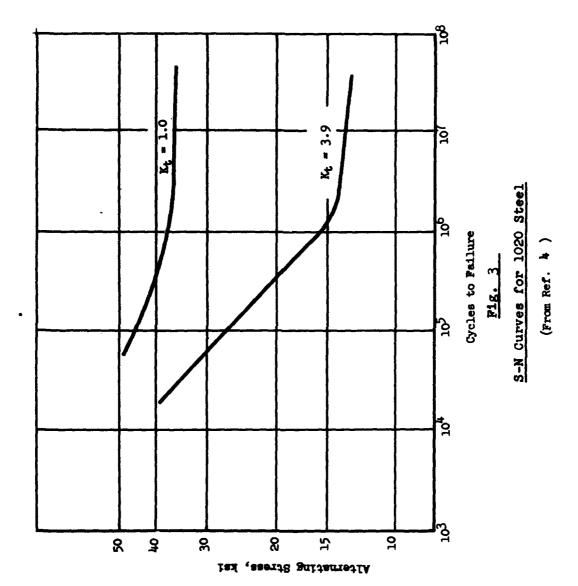
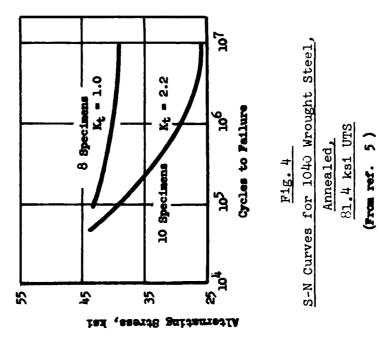


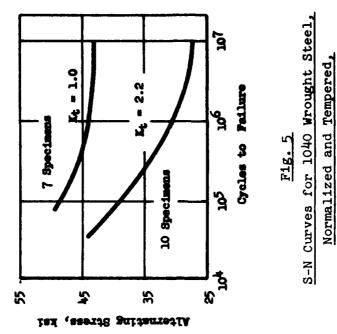
Fig. 2
S-N Curves for SAE 1008 Steel, Decarburized
and Not Decarburized
(From ref. 3)



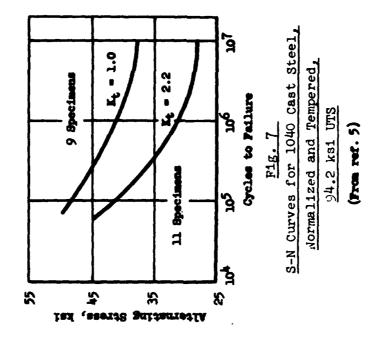


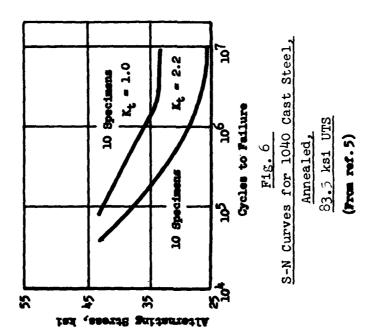


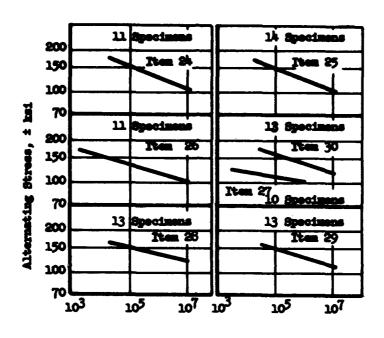




90 ks1 UTS





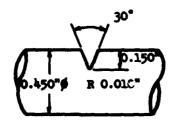


Cycles to Failure

Fig. 8

S-N Curves - Carburized 2315 Steel, Smooth

(From Ref. 6)



Design of Notch Used For Fatigue Tests of Carburized Steels

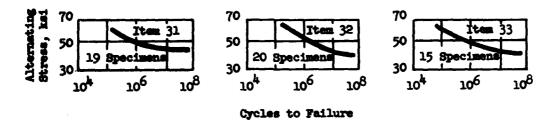


Fig. 10

S-N Curves - Notched 2315 Carburized Steel

(Stresses are arbitrary and may be misleading)

(From Ref. 6)

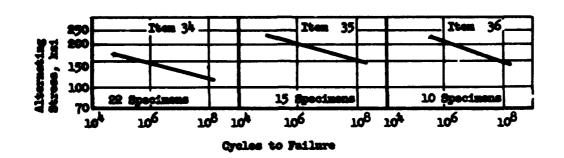
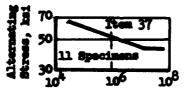
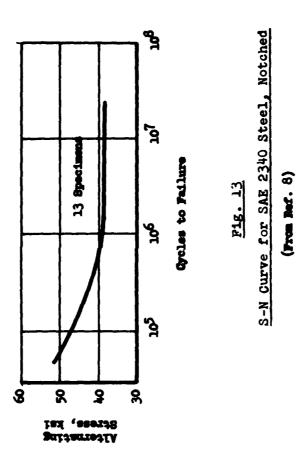


Fig. 11
S-N Curves - Smooth 2330 Carburized Steel



Cycles to Failure

Fig. 12
S-N Curves - Notched 2330 Carburized Steel



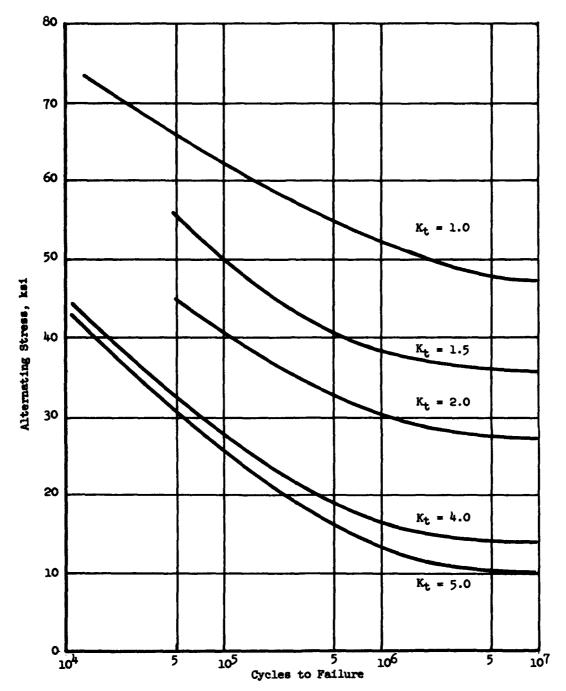


Fig. 14

Approximate S-N Curves for Normalized 4130 Steel.

Fully Reversed Axial Stresses

(Plotted from Table 7 of Ref. 10)

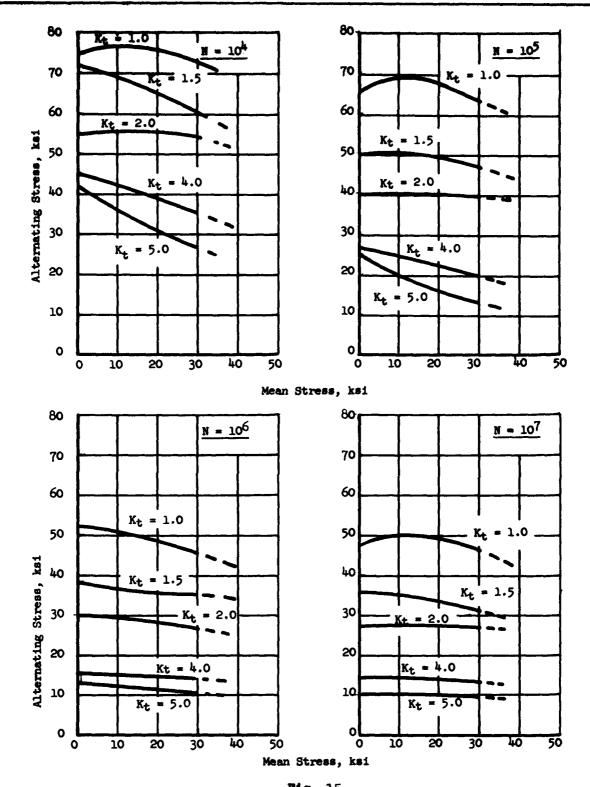


Fig. 15

Alternating vs. Mean Stress, for Normalized 4130 Steel

Axial Stresses

(Plotted from Table 7 of Ref. 10)

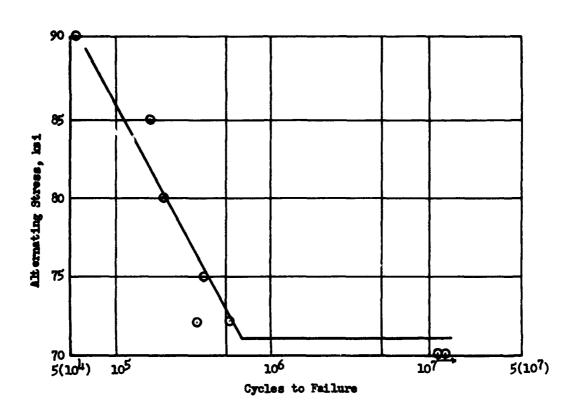


Fig. 16

S-N Curve - Steel SAE 4320 - "Transverse" Specimens

(Traced from ref. 11)

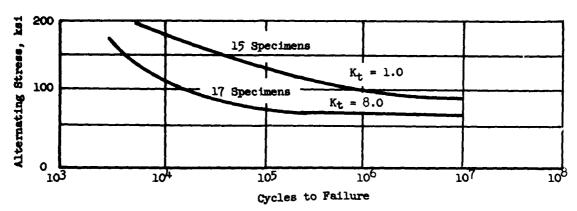


Fig. 17

S-N Curves for V-Modified 4330 Steel, 263 ksi UTS

(From Ref. 13)

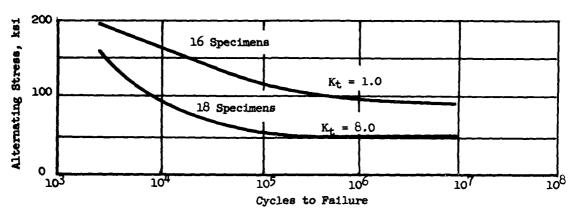
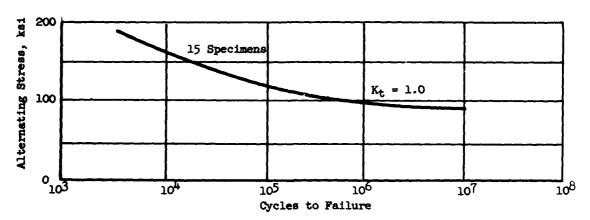


Fig. 18

S-N Curves for V-Modified 4330 Steel, 250 ksi UTS

(From Ref. 13)



F1g. 19

S-N Curves for Smooth V-Modified 4330 Steel, 236 ksi UTS

(From Ref. 13)

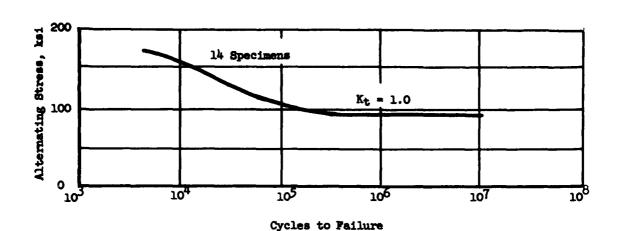
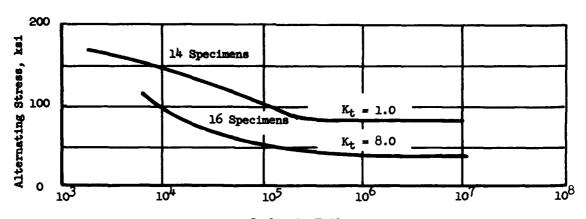


Fig. 20
S-N Curves for Smooth V-Modified 4330 Steel, 222 ksi UTS

(From Ref. 13)



Cycles to Failure

Fig. 21

S-N Curves for V-Modified 4330 Steel, 201 ksi UTS

(From Ref. 13)

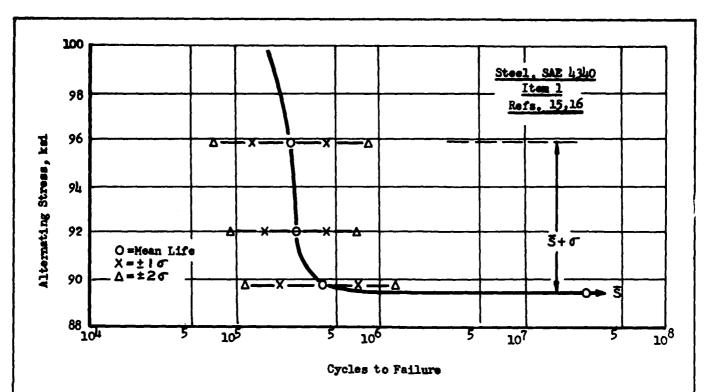


Fig. 22
Statistical Variation in Fatigue Life and Endurance Limit
For Quenched and Tempered SAE 4340

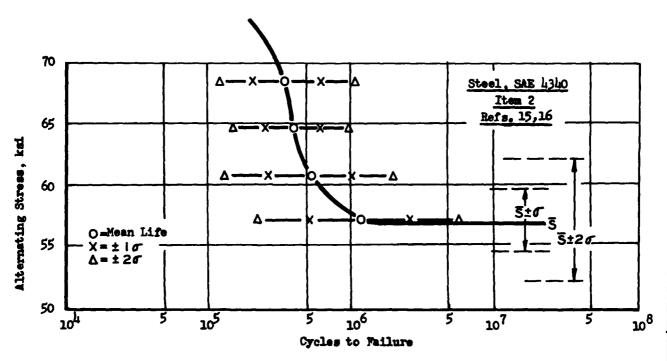


Fig. 23
Statistical Variation in Fatigue Life and Endurance Limit
of Quenched and Spheroidized SAE 4340

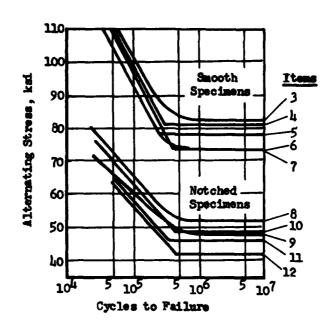


Fig. 24
S-N Curves for SAE 4340 Steel, UTS 164 ks1
(Traced from ref.17)

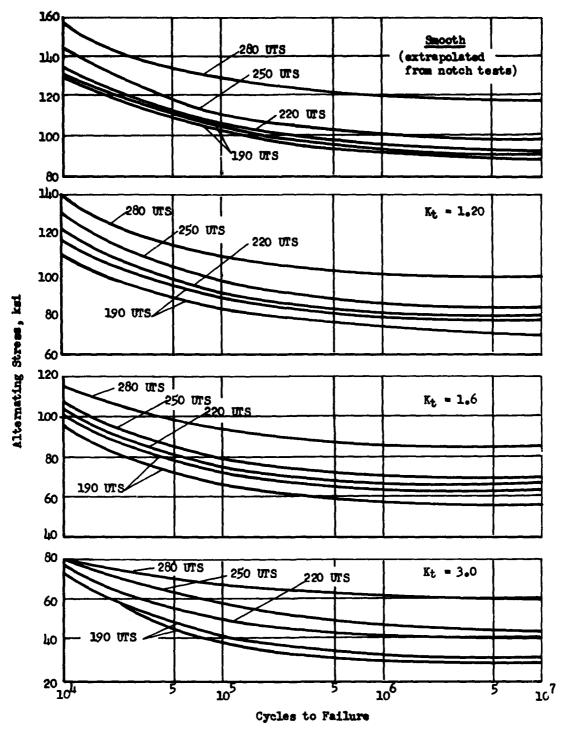
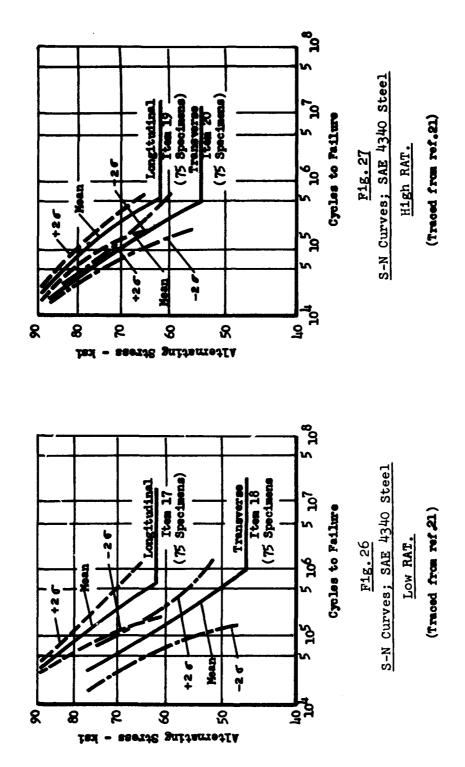


Fig.25
S-N Curves, for Fully Reversed Axial Stress,
of SAE 4340 Steel
(Based on ref.20)



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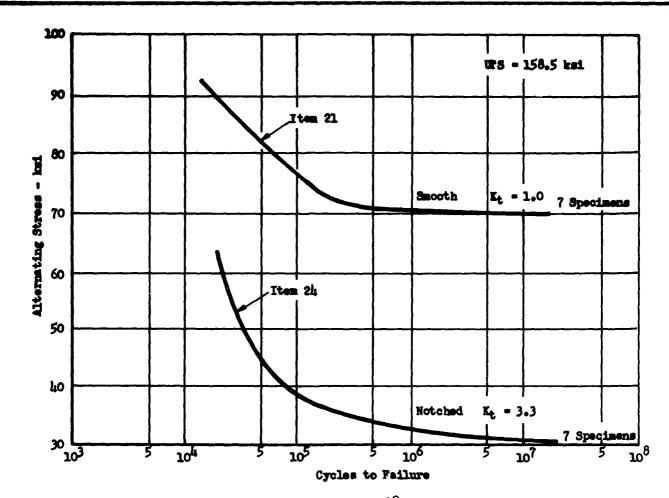


Fig. 28

"Fully Reversed" S-N Curves for SAE 4340 Steel - Room Temp.

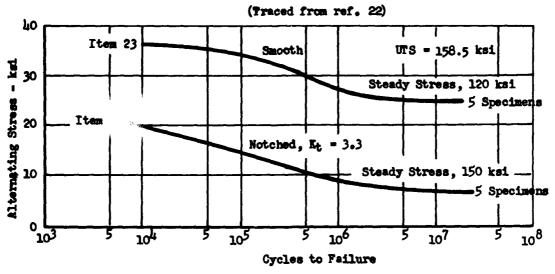
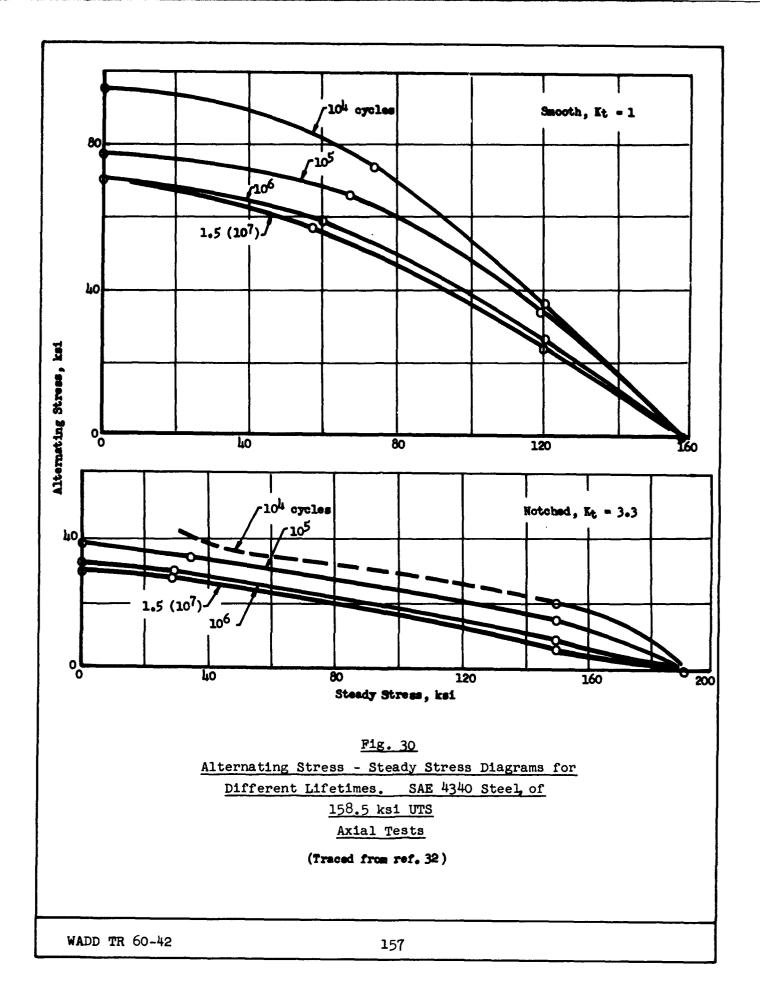
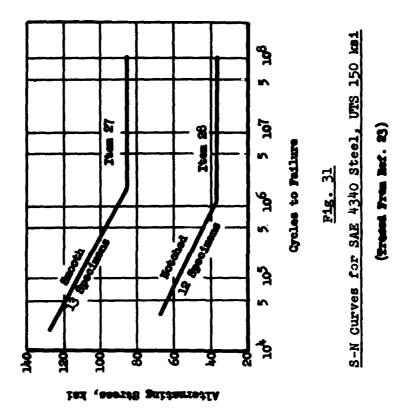


Fig. 29
S-N Curves for SAE 4340 Steel - Room Temp. - With Steady Stress
(From ref. 22)





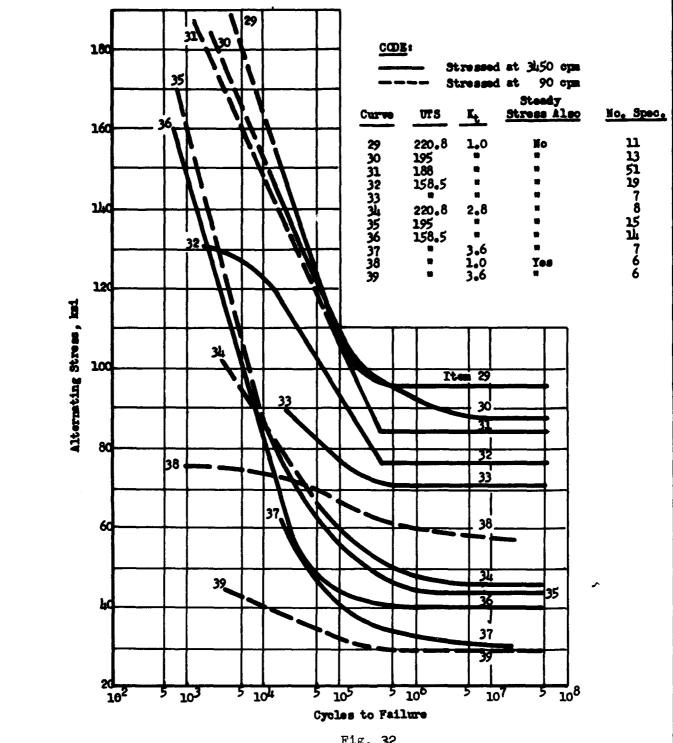


Fig. 32
S-N Curves for SAE 4340 Steel

(Plotted from scaled readings on charts in ref. 24)

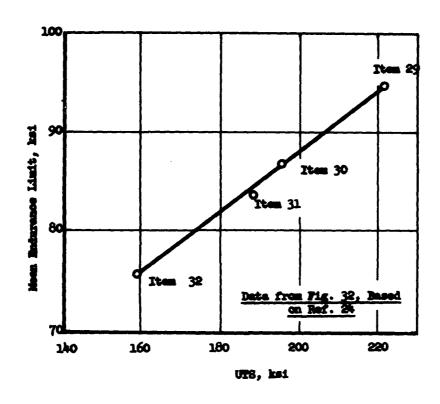


Fig. 33

Mean Endurance Limit vs. UTS of SAE 4340 Steel

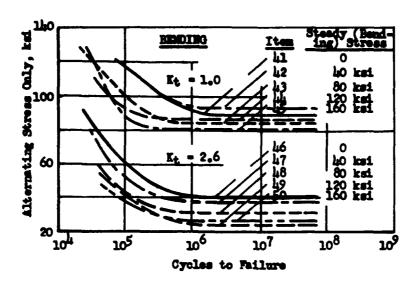


Fig. 34

S-N Curves for SAE 4340 Steel, 172 ksi UTS

Tested in Bending

(Same Stresses have been corrected for yielding)

(Traced from ref. 26)

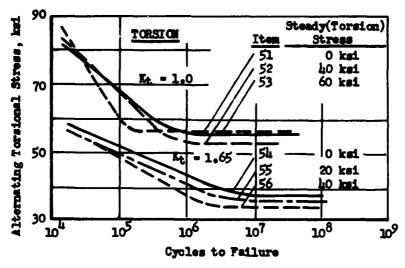


Fig. 35
S-N Curves for SAE 4340 Steel, 172 ksi UTS
Tested in Torsion

(Some Stresses have been corrected for yielding)
(Traced from ref. 26)

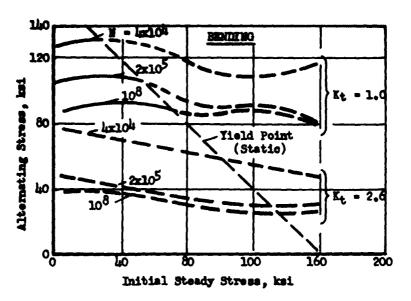


Fig. 36
Alternating vs. Steady Bending Stresses
for SAE 4340 Steel, 172 ksi UTS
(Traced from ref. 26)

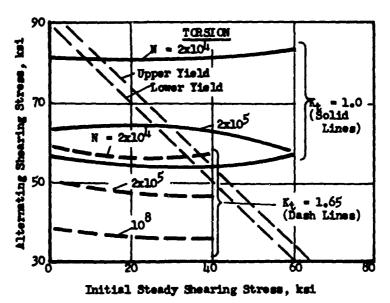
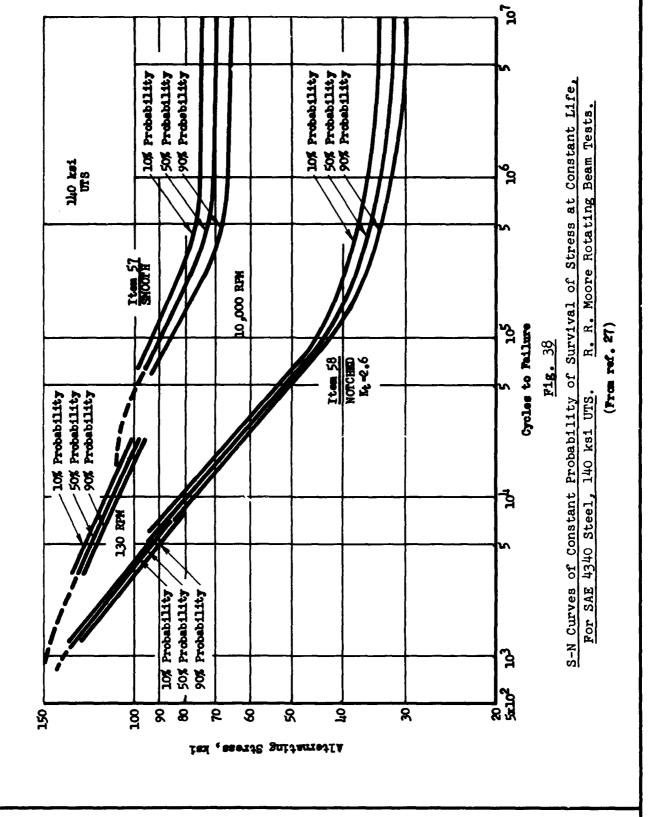


Fig. 37

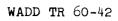
Alternating vs. Steady Shearing (Torsion)

Stresses, for SAE 4340 Steel, 172 ksi UTS

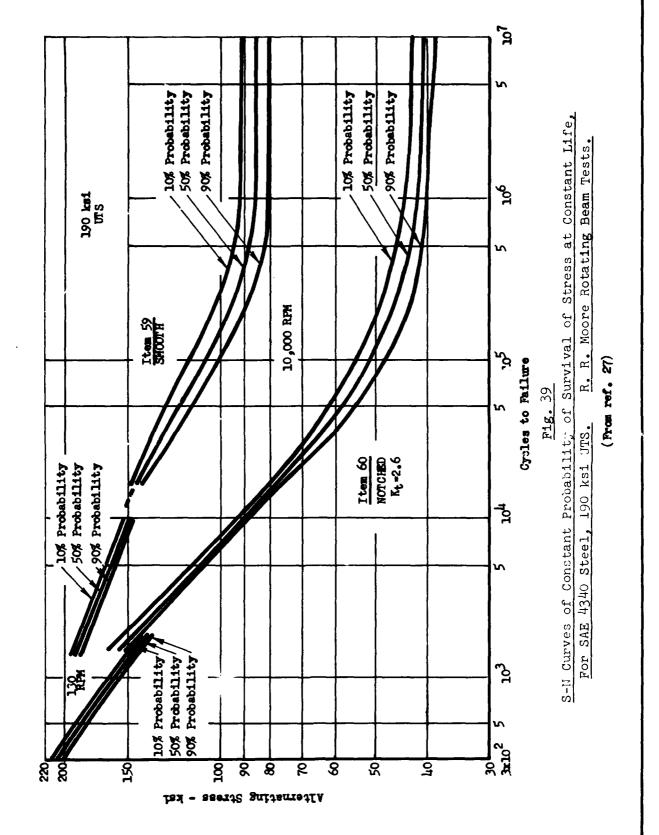
(Traced from ref. 26)

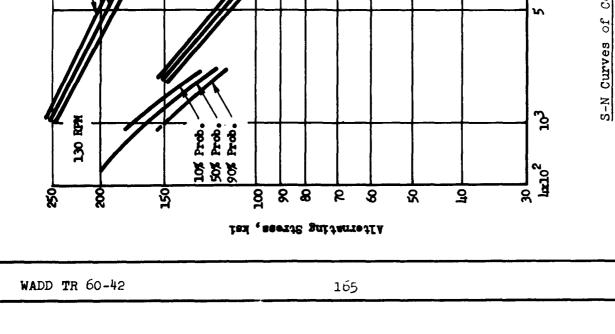


WADD TR 60-42









50% Probability 90% Probability

10% Probability

10,000 RPH

Item 62 NOTCHED Kt =2.6

50% Probability

-90% Probability

10% Probability

Item 61 SHOOTH

260 bs1 UTS

- 10% Probability - 50% Probability - 90% Probability

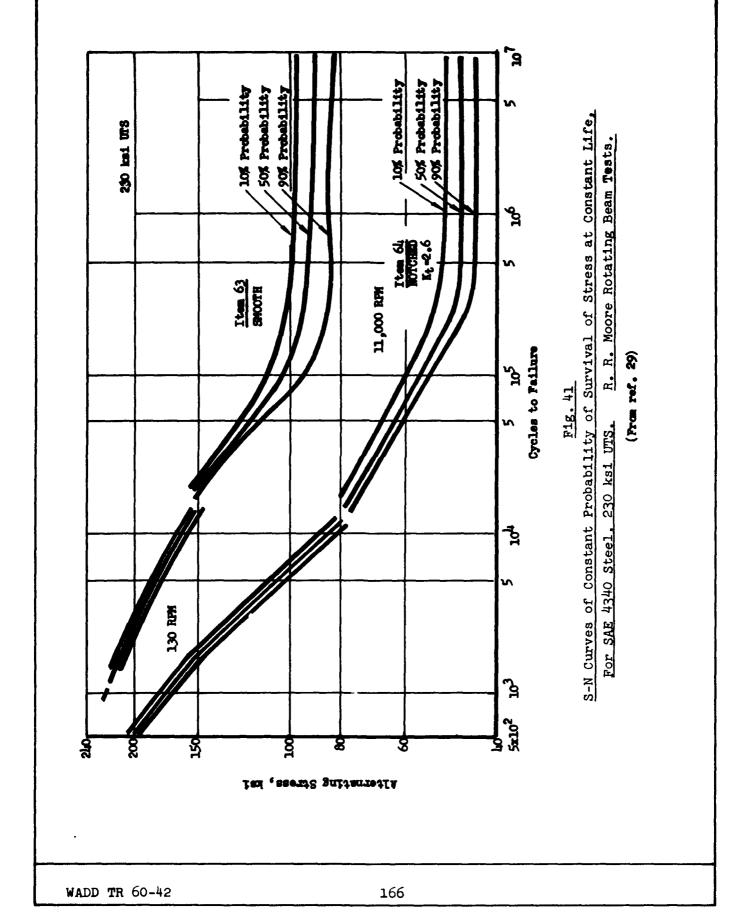
S-N Curves of Constant Probability of Survival of Stress at Constant Life, Moore Rotating Beam Tests R. R. Cycles to Failure F1g. 40 260 ks1 UTS. For SAE 4340 Steel,

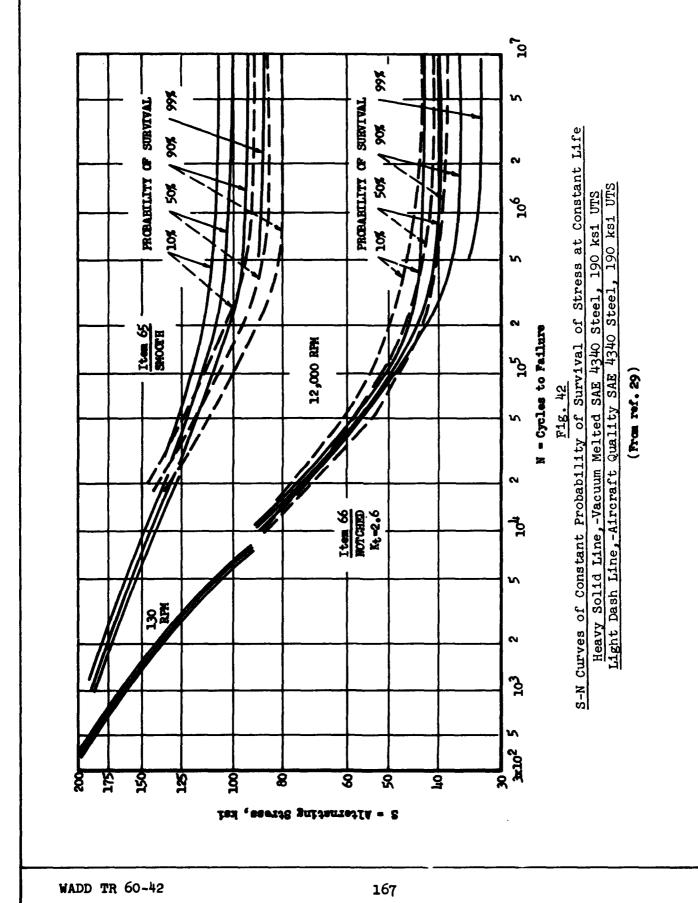
'9

901

701

(From ref. 27)





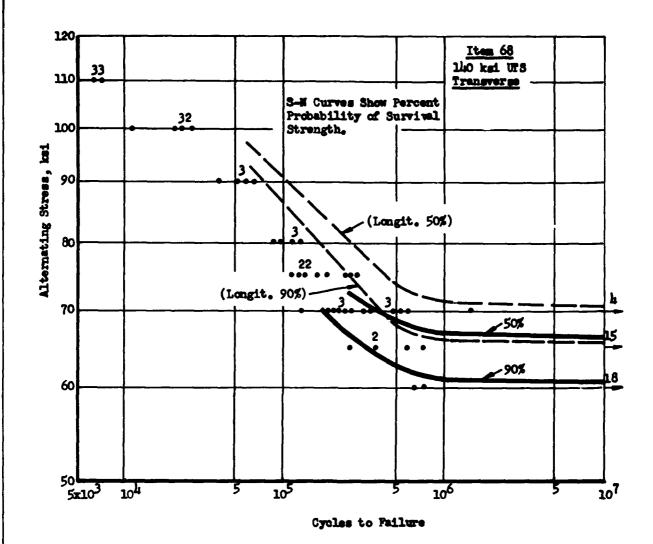


Fig. 43

Tests of SAE 4340 Steel, UTS 140 ksi

Transverse Smooth Specimens
R. R. Moore Rotating Bending Tests
(From ref. 30)
(Light dash lines show longitudinal values)

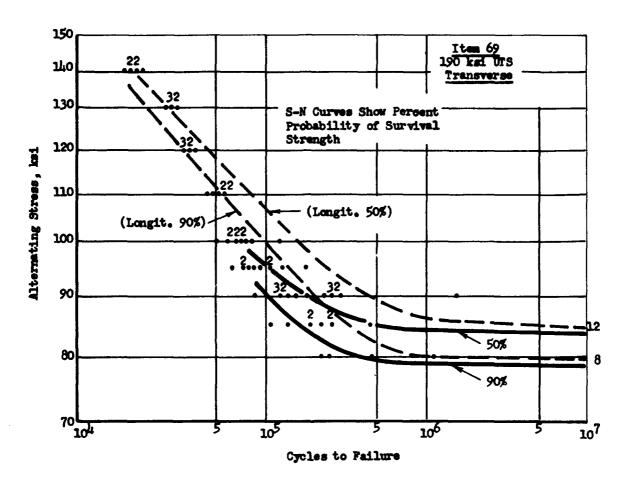


Fig. 44

Tests of SAE 4340 Steel, UTS 190 ksi

Transverse Smooth Specimens
R. R. Moore Rotating Bending Tests

(From ref. 30)

(Light dash lines show longitudinal values)

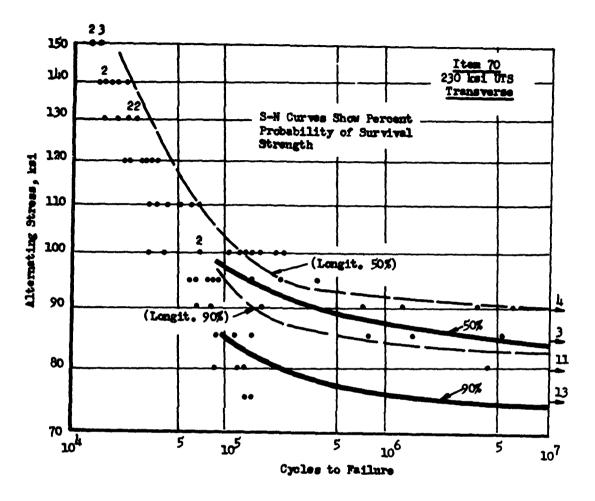


Fig. 45

Tests of SAE 4340 Steel, UTS 230 ksi

Transverse Smooth Specimens
R. R. Moore Rotating Bending Tests

(From ref. 30)

(Light dash lines show lengitudinal values)

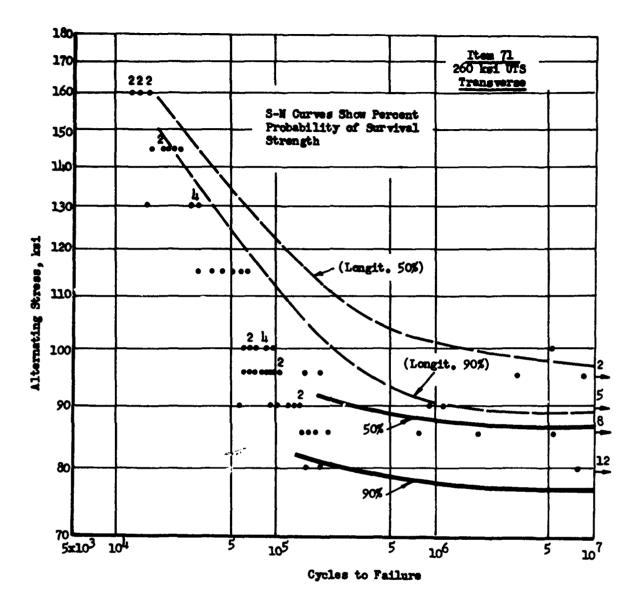


Fig. 46

Tests of SAE 4340 Steel, UTS 260 ksi

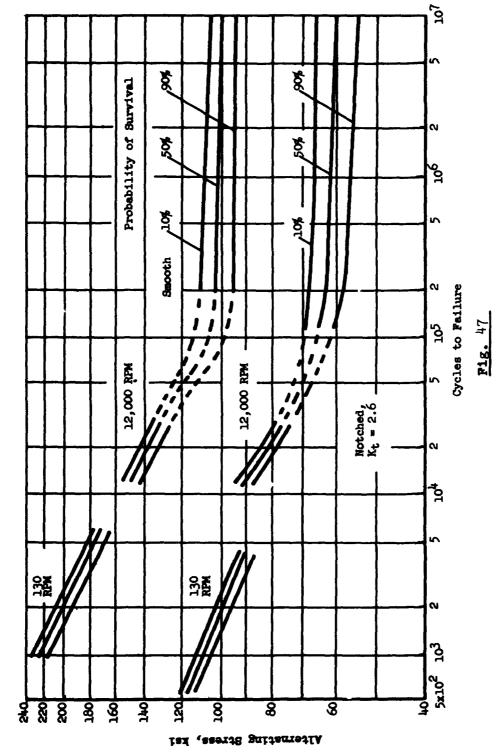
Transverse Smooth Specimens
R. R. Moore Rotating Beam Tests

(From ref. 30)

(Light dash lines show longitudinal values)



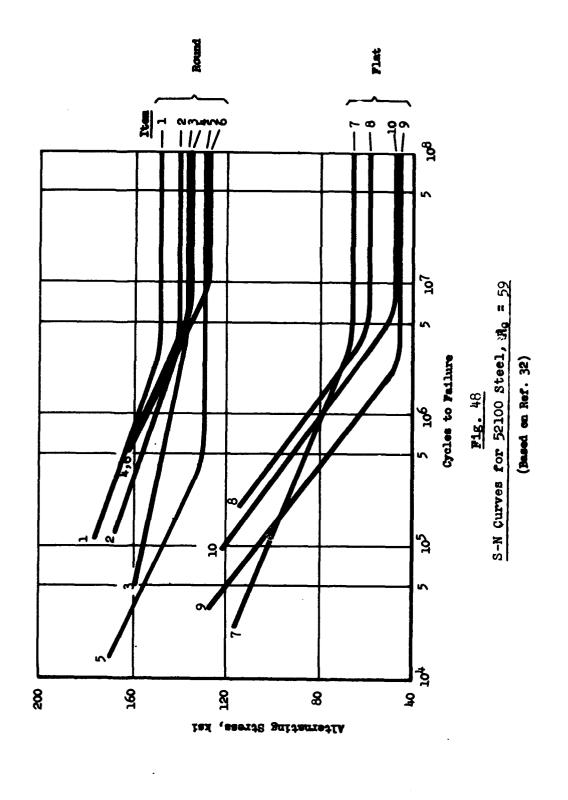


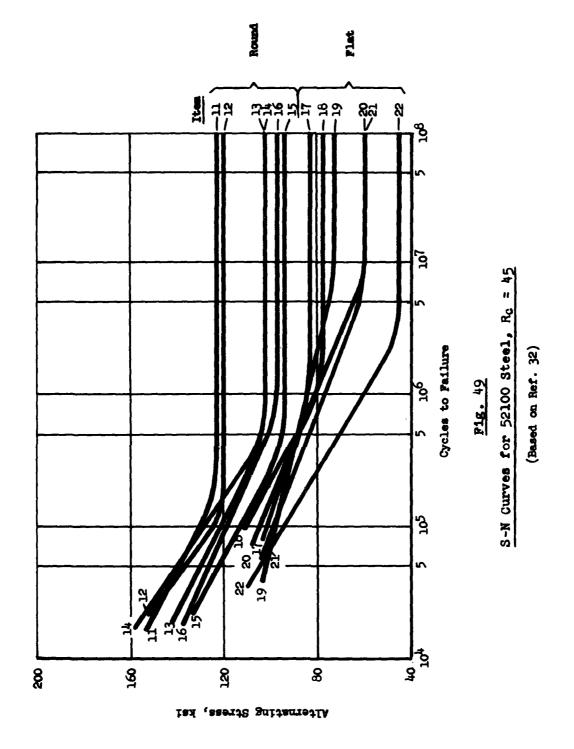


S-N Curves of Constant Probability of Survival of Stress at Constant Life R. R. Moore Rotating Beam Tests of 4350 Steel, 300 ksi UTS

(Dash lines connect curves whose position was computed.)

From Ref. 20





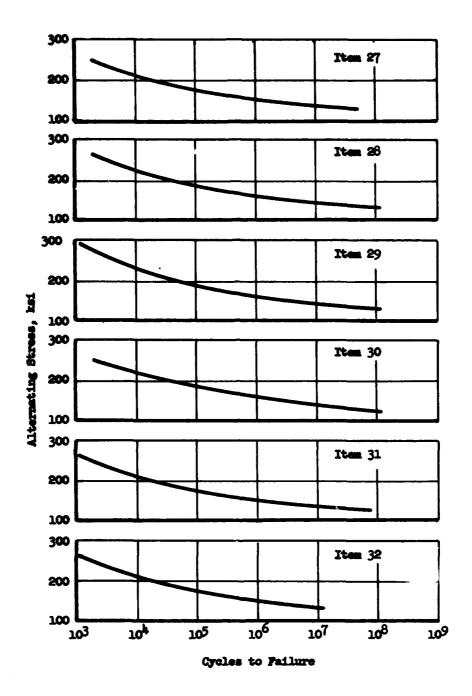
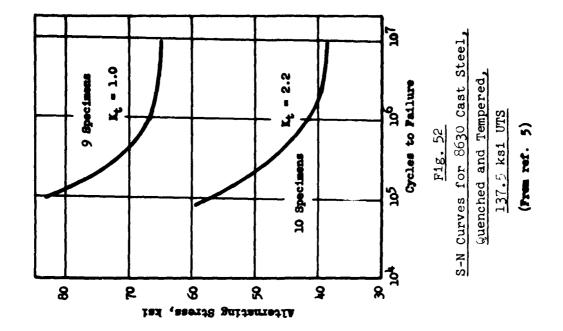
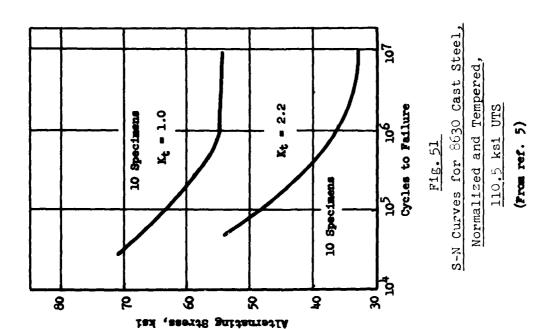


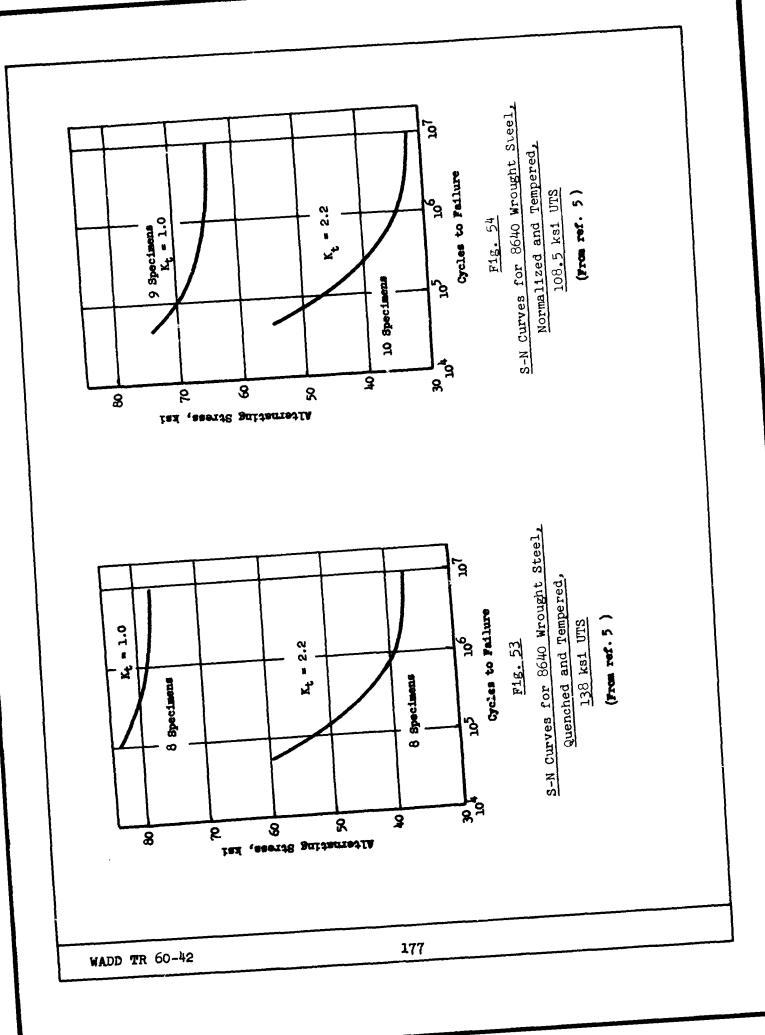
Fig. 50

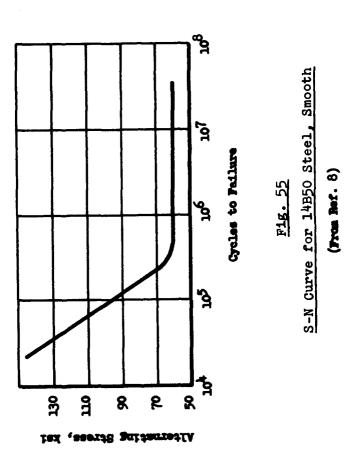
S-N Curves - 52100 Steel, Rotating Beam Specimens

(Based on Ref. 33)

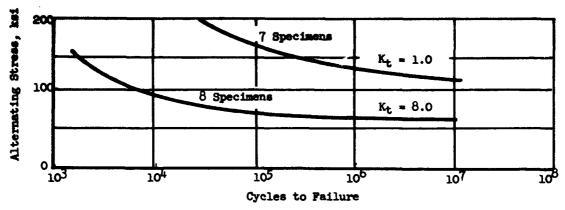








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F1g. 56

S-N Curves for 98840 Steel, 302.6 kmi UTS

(From Ref. 13)

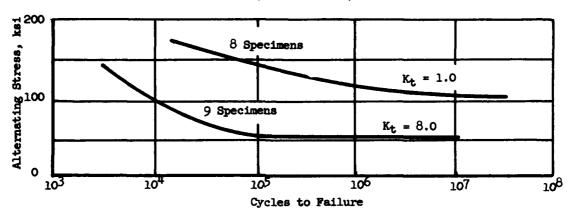


Fig. 57

S-N Curves for 98B40 Steel, 284 ks1 UTS

(From Ref. 13)

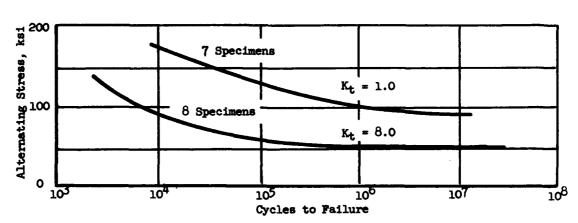


Fig. 58

S-N Curves for 98B40 Steel, 270 ksi UTS

(From Ref. 13)

WADD TR 60-42

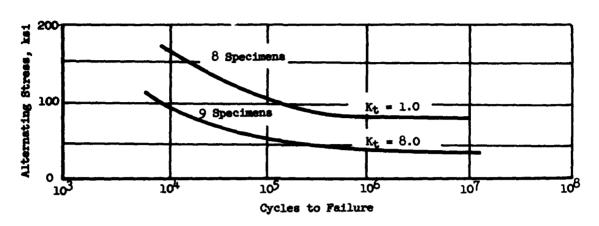


Fig. 59
S-N Curves for 98B40 Steel, 245 ks1 UTS
(From Ref. 13)

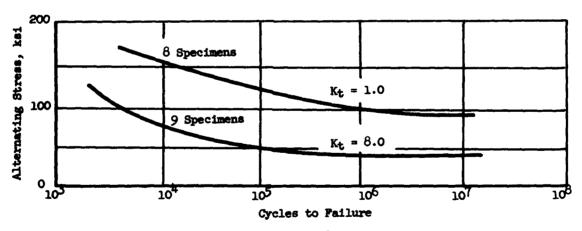
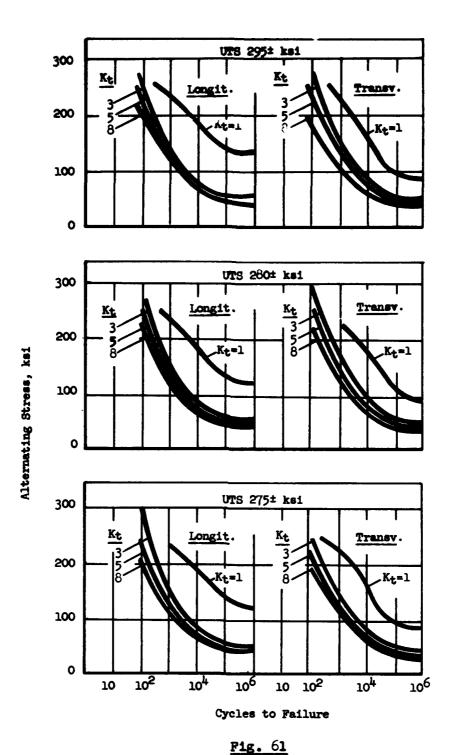


Fig. 60
S-N Curves for 98B40 Steel, 204 ks1 UTS
(From Ref. 13)



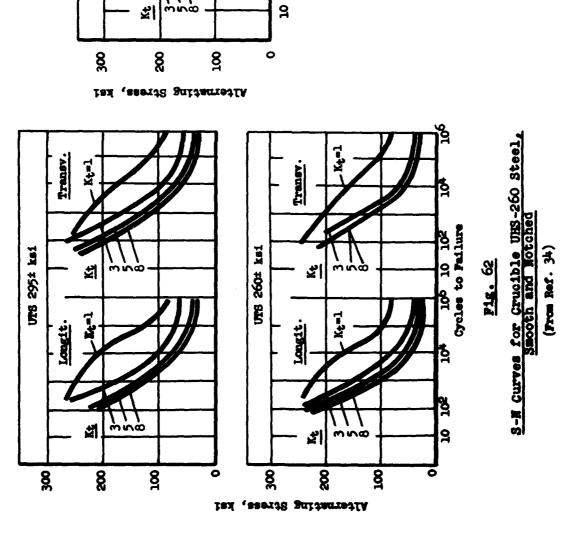
S-N Curves for Tricent Steel, Smooth and Notched
(From Ref. 34)

Transv

Longit.

UTS 2704 ks1

3



S-N Curves for Super TM-2 Steel.
Smooth and Notched
(From Ref. 34)

Cycles to Failure

106 10 102

70₹

% %

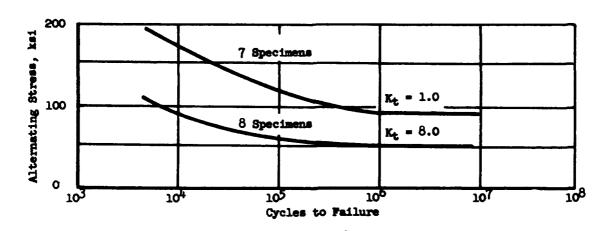


Fig. 64
S-N Curves for Hy-Tuf Steel, 243 ks1 UTS
(From Ref. 13)

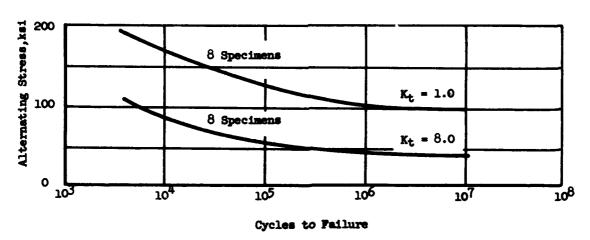


Fig. 65

S-N Curves for Super Hy-Tuf Steel, 260 ks1 UTS

(From Ref. 13)

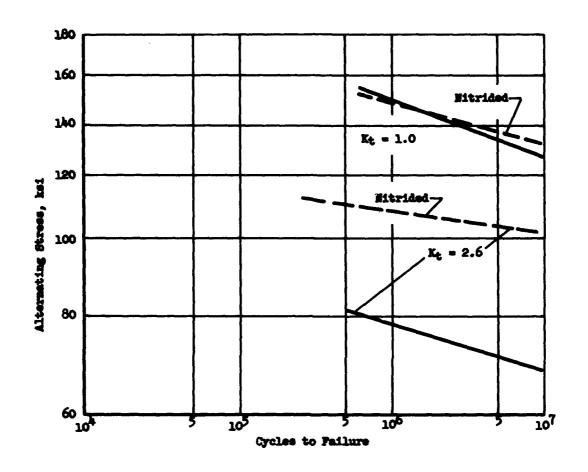


Fig. 66

Approximate S-N Curves for Ferrovac WB-49 Steel,
Not Nitrided, and Nitrided

(From ref. 35)

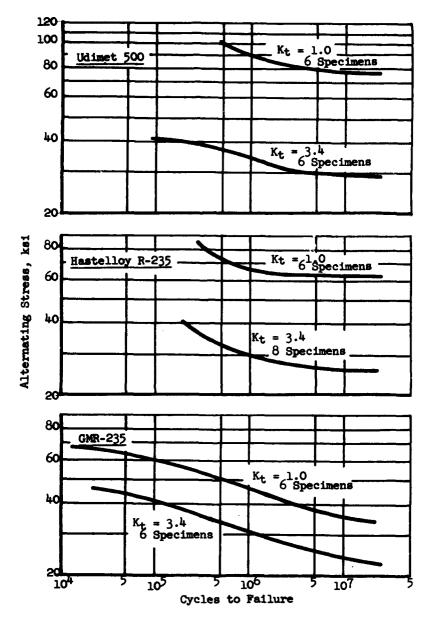
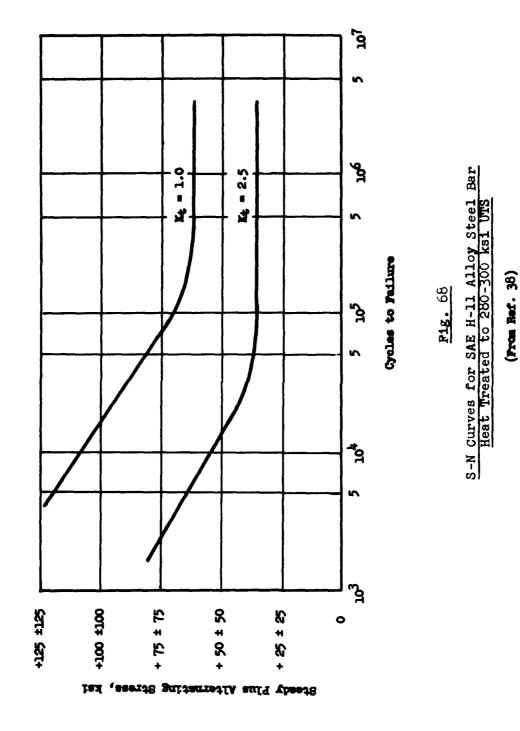


Fig. 67

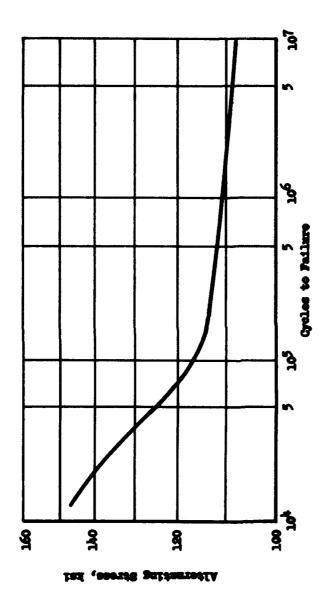
S-N Curves for Udimet 500, Hastelloy R-235, and GMR-235 Heat Resistant Alloys

(From Ref. 36)

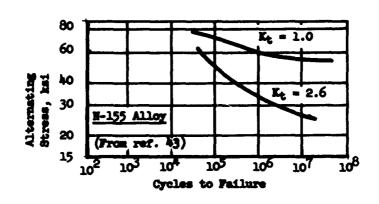


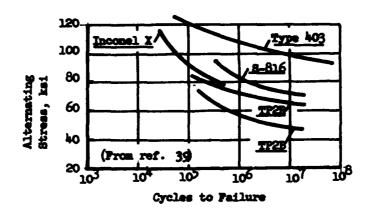
186

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S-N Curve for H-23 Hot Work Tool Steel
(From ref. 35)

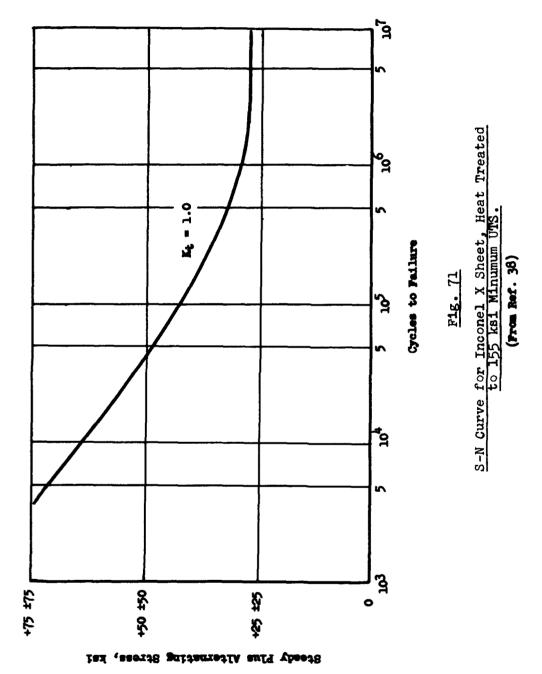


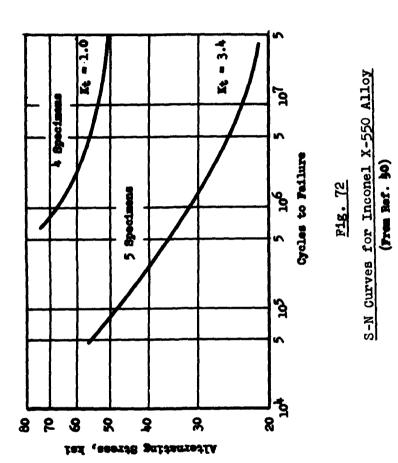


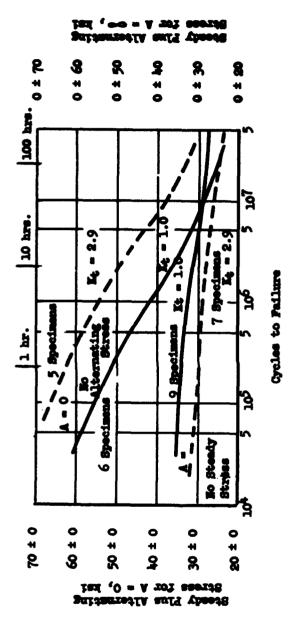
S-N Curves for Heat Resistant Alloys
Tested at Room Temperature





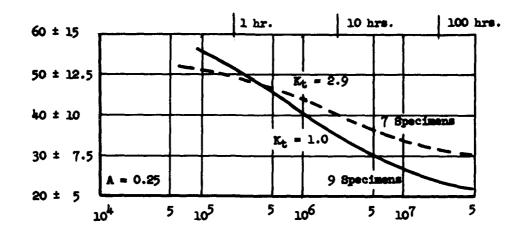


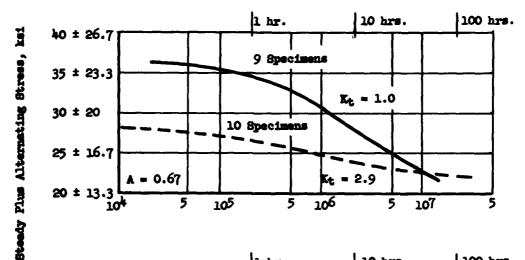




1700°F S-N Curves for Inconel 713C at Zero Steady Stress and at Zero Alternating Stress (From Nef. %1)

Note: A = ratio of elternating to steady stress





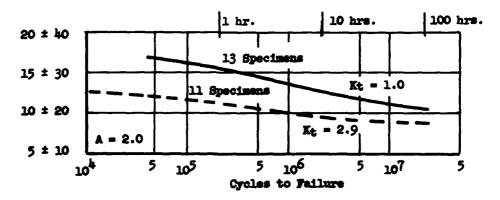
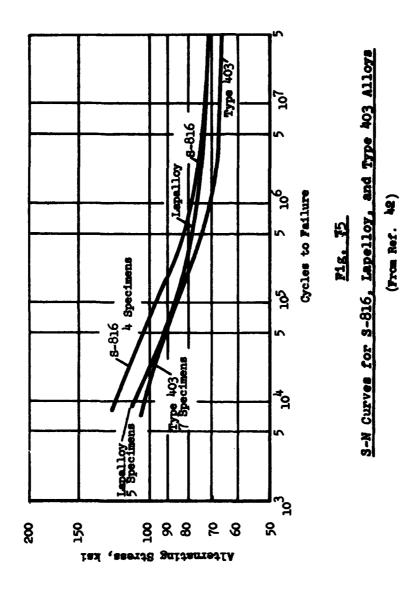


Fig. 74

1700°F S-N Curves for Inconel 713C at Several Combinations of Steady and Alternating Stress

(From Ref. 41)

Note: A = ratio of alternating to steady stress.



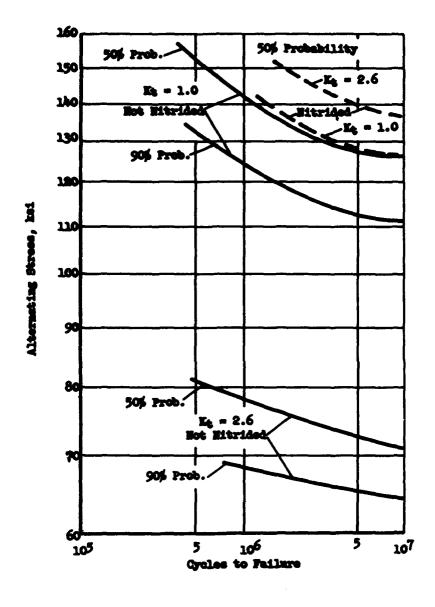
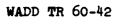


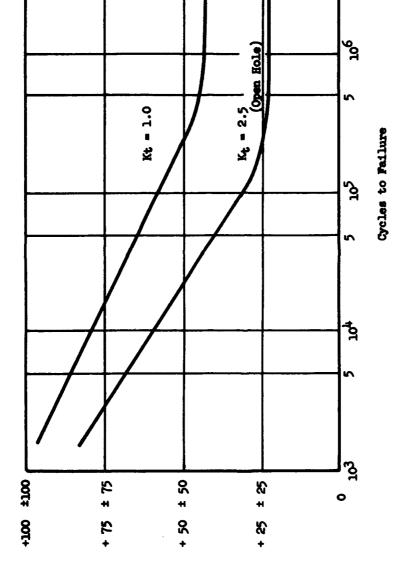
Fig. 76

S-N curves for M-10 Steel, Rc 61-62, Not Nitrided and Nitrided. Constant Probability of Survival of Stress at Constant Life.

(From ref. 35)





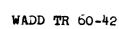


Steady Plus Alternating Stress, kai

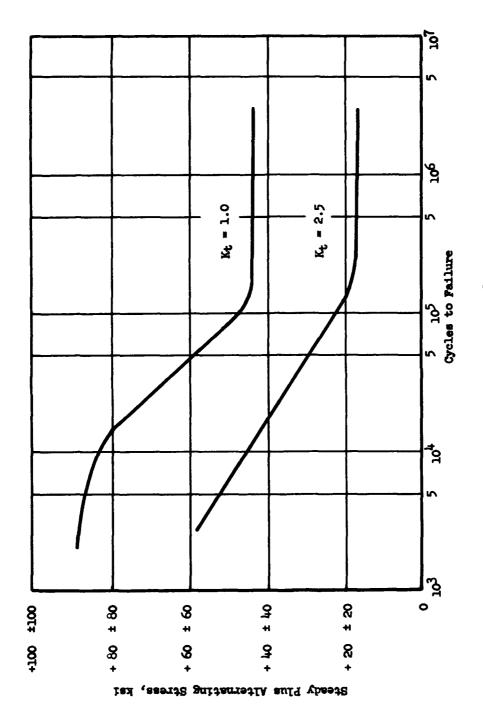
S-N Curves for PH 15-7 Mo Stainless Steel, Condition HH950, Heat Treated to 225 ksi Minimum UTS

701

(From Ref. 38)







S-N Curves for 17-7 PH Stainless Steel, Condition TH 1050, Heat Treated to 180 ksi Minimum UTS

(From Ref. 38)

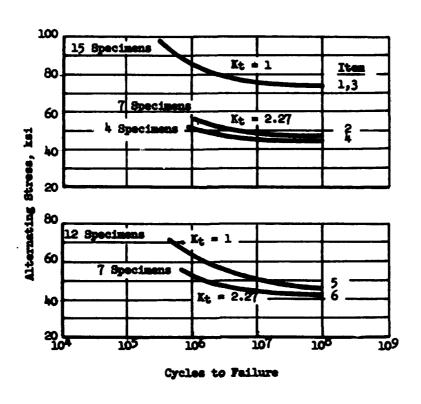


Fig. 79

S-N Curves for Refractaloy 26

At Room Temperature

(From ref. 44)

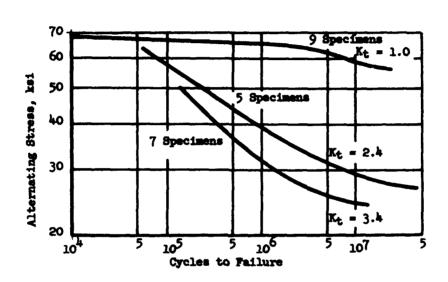
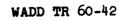
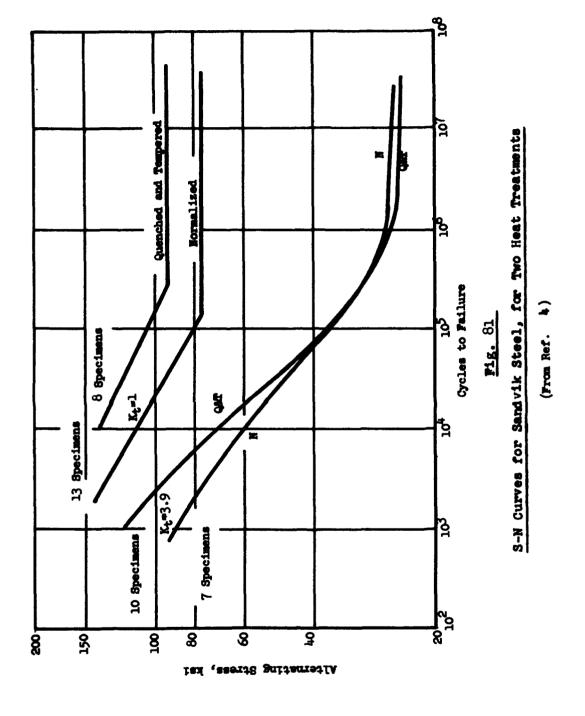


Fig. 80
S-N Curves for S-816 Alloy

(From Ref. 40)







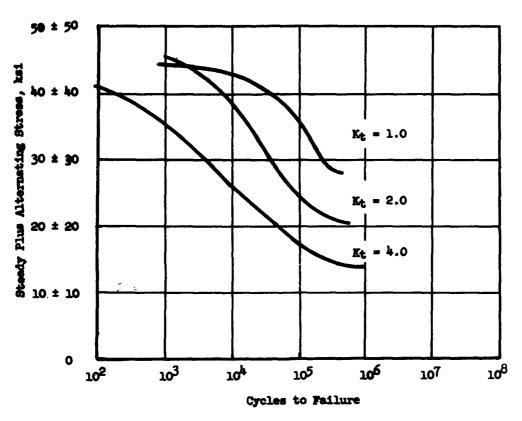


Fig. 82

S-N Curves for 347 Stainless Steel, Showing Steady
Plus Alternating Stress

(From Ref. 45)

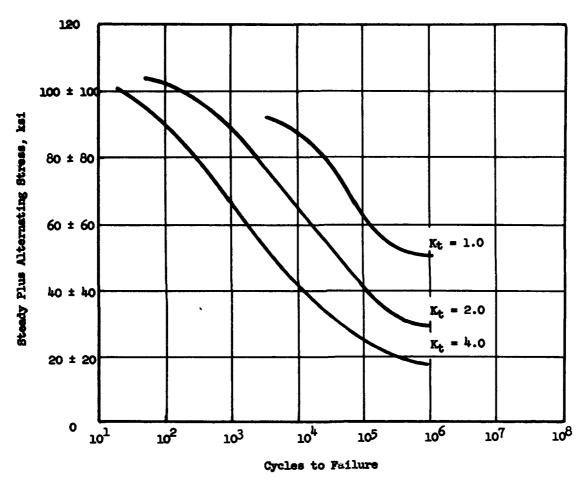


Fig. 83

S-N Curves for 403 Stainless Steel, Showing Steady
Plus Alternating Stress

(From Ref. 45)

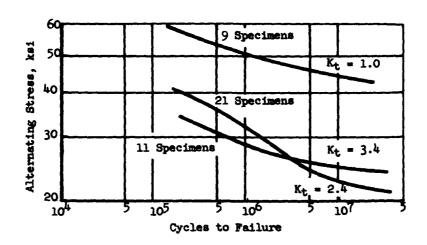


Fig. 84
S-N Curves for Stellite 31 (X-40) Alloy
(From Ref. 40)

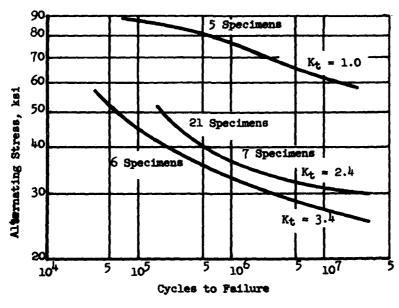
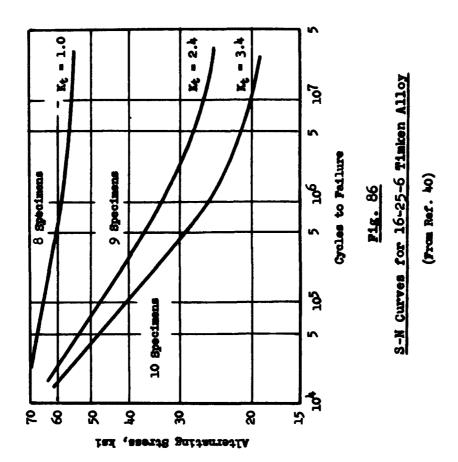


Fig. 85
S-N Curves for 6.36 Mo-Waspalloy
(From Ref. 40)



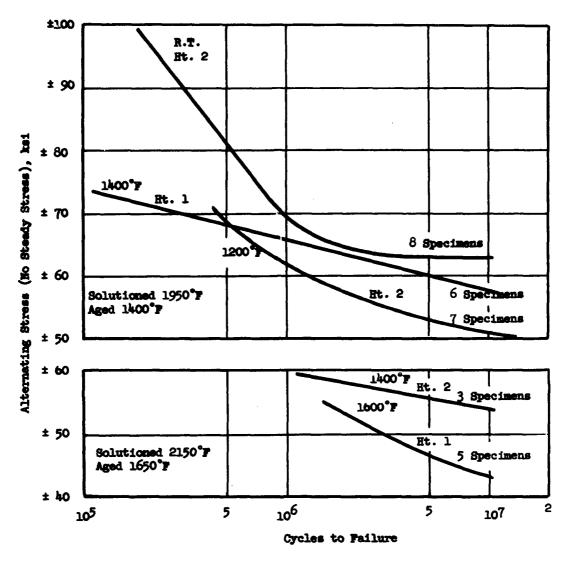
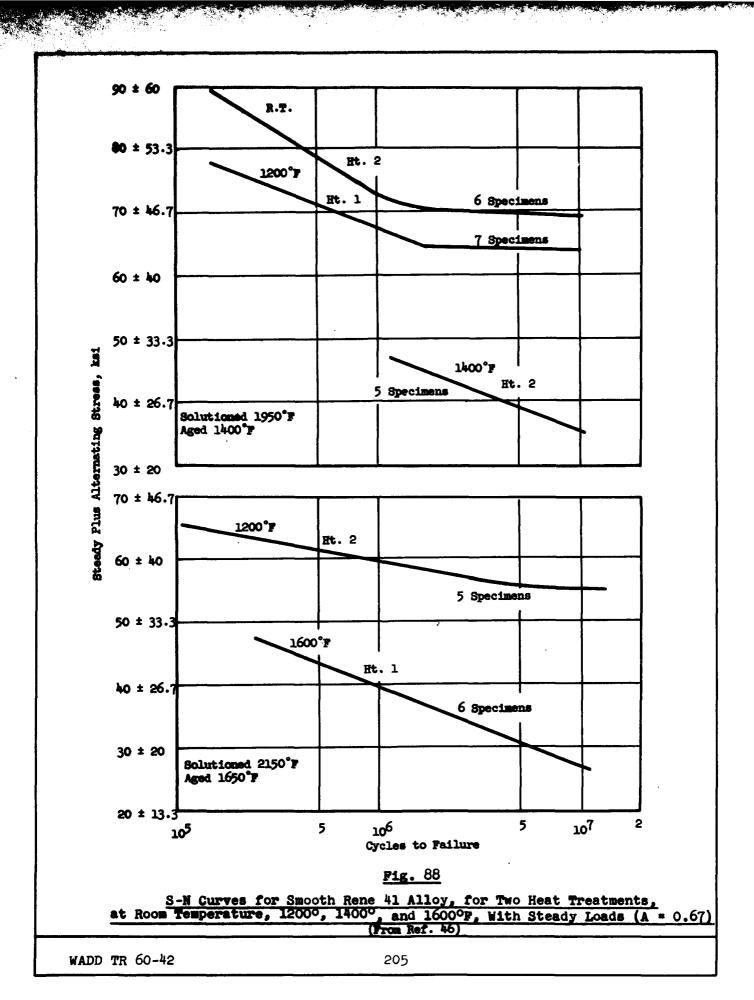
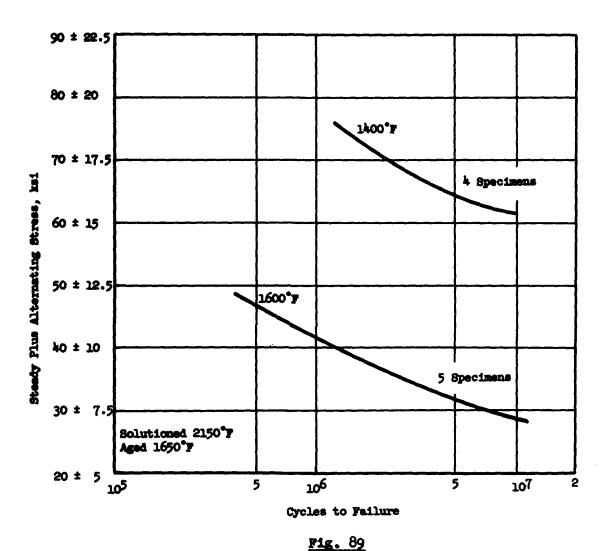


Fig. 87

(From Ref. 46)





S-N Curves for Smooth Rene 41 Alloy, for One Heat Treatment, at 14000 and 16000F, With Steady Loads (A = 0.25) (From Ref. 46)

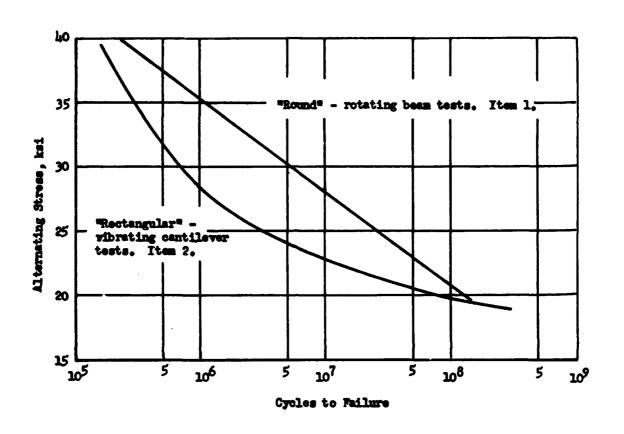


Fig. 90
S-N Curves for Aluminum Alloy 2014 (14S-T), Extruded
(From ref. 47)

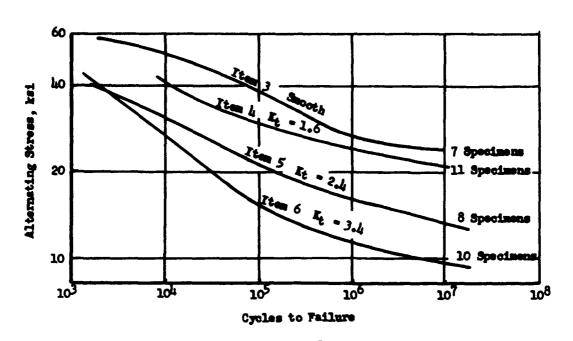


Fig. 91
S-N Curves for Aluminum Alloy 2014-T6 (14S-T6), Rolled.
(From ref. 48)

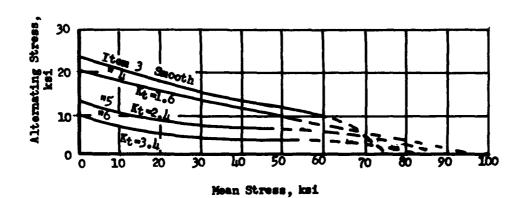
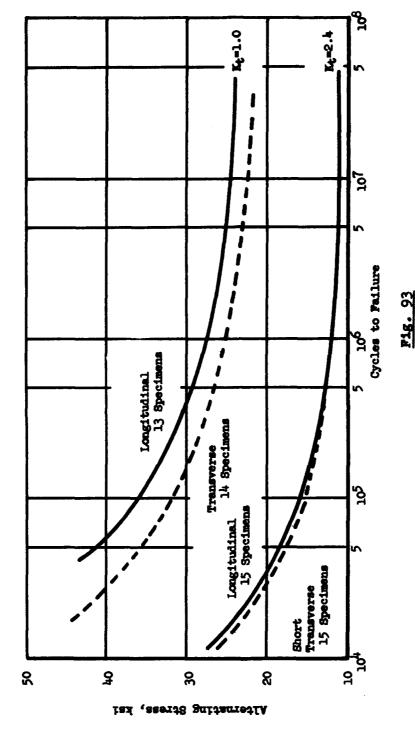


Fig. 92

Alternating vs. Mean Stress, for N = 10⁷ Cycles,

for 14S-T6 Aluminum Alloy, Rolled.

(From ref. 48)



S-N Curves for 2014-T6 Aluminum Alloy, Hand Forged Longitudinal, and Short Transverse, Axial Tests.

(From Ref. 49)

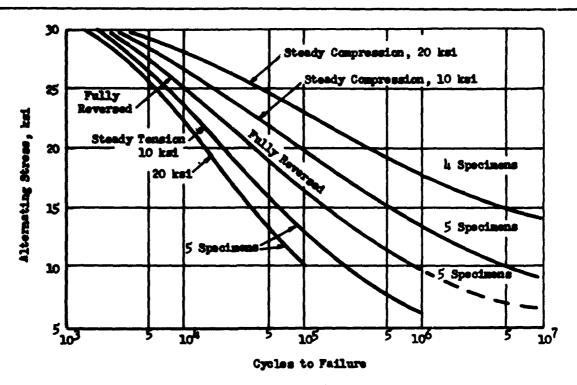


Fig. 94
S-N Curves for Notched Alclad 24S-T3, Kt = 2.5

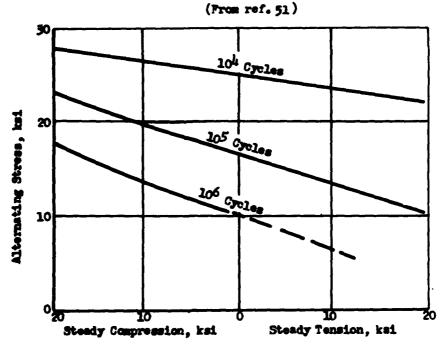


Fig. 95

Alternating vs. Steady Stress for Notched

Alclad 24S-T3, Kt = 2.5

(From ref. 51)

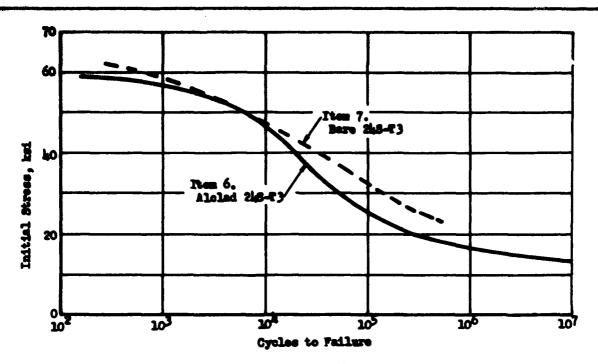


Fig. 96
S-N Curves for Alclad and for Bare 24S-T3, Smooth

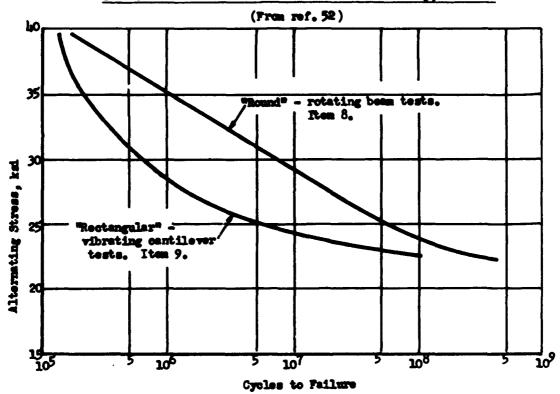


Fig. 97
S-N Curves for Aluminum Alloy 24S-T, Extruded
(From ref. 47)

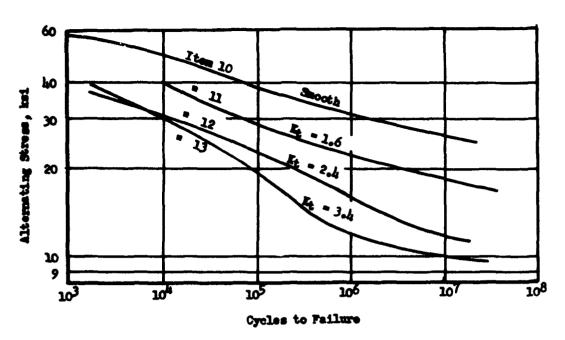


Fig. 98
S-N Curves for 24S-T4 Aluminum Alloy, Rolled.
(From ref. 48)

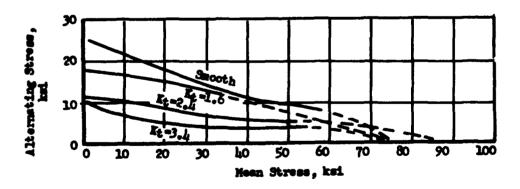
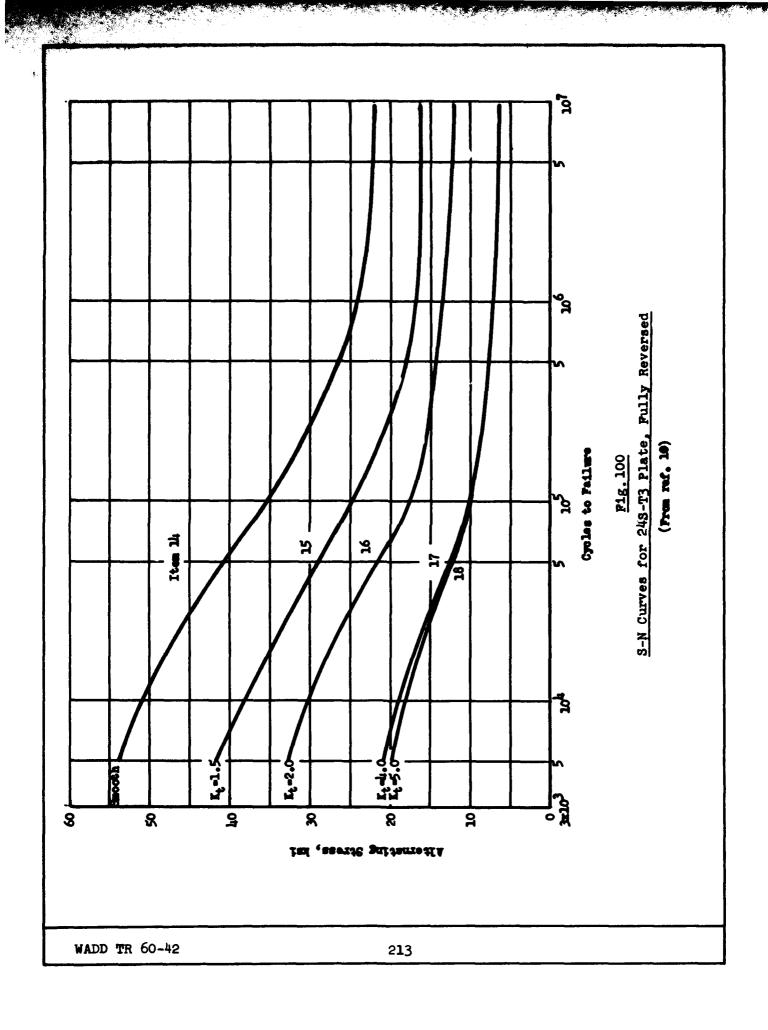


Fig. 99

Alternating vs. Mean Stress, for N = 107 Cycles
for 24S-T4 Aluminum Alloy, Rolled

(From ref. 48)



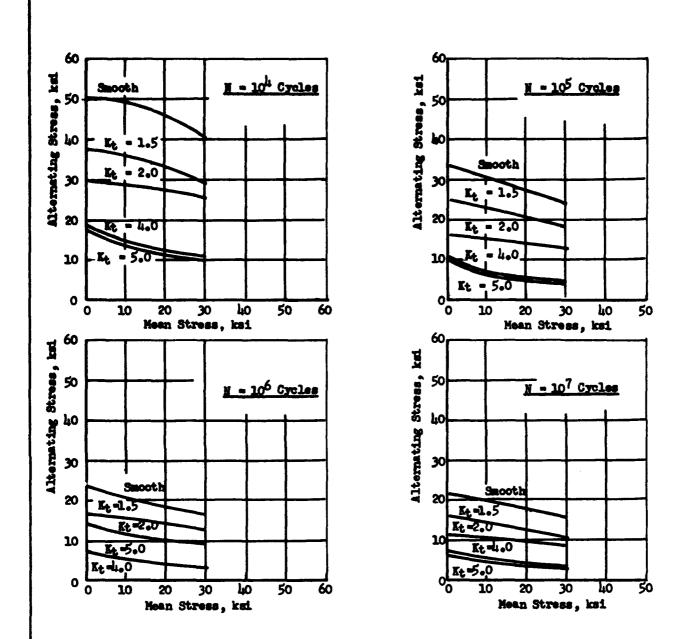


Fig. 101
Alternating vs. Mean Stress for 24S-T3
Aluminum Alloy Plate

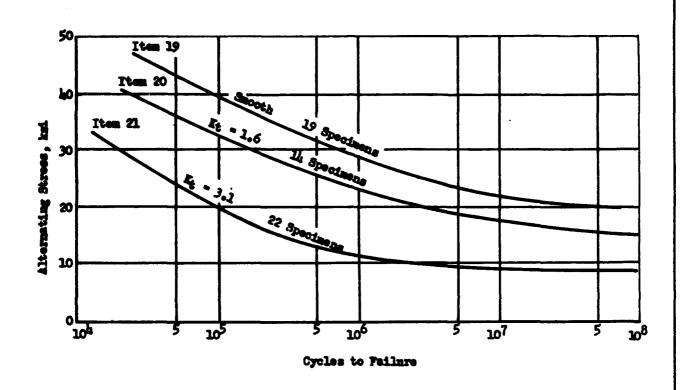
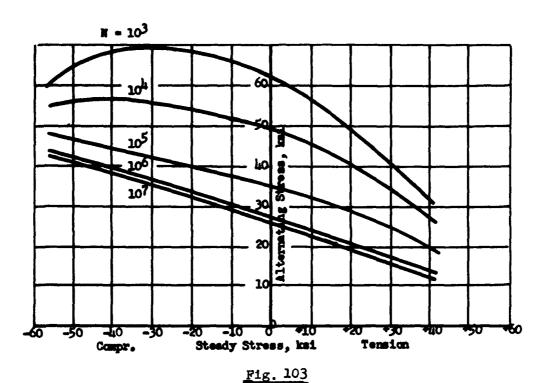


Fig. 102
S-N Curves for 24S-T4 Aluminum Alloy, Hot Rolled.
(From ref. 55)



Alternating vs. Steady Stress, for Aluminum Alloy 24S-T, Smooth
(Based on axial tests of 98 specimens)

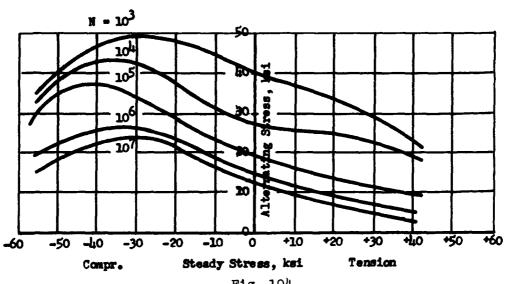


Fig. 104

Alternating vs. Steady Stress, for Aluminum Alloy 24S-T,

Notched, Kt = 2.05

(Based on axial tests of 106 specimens)

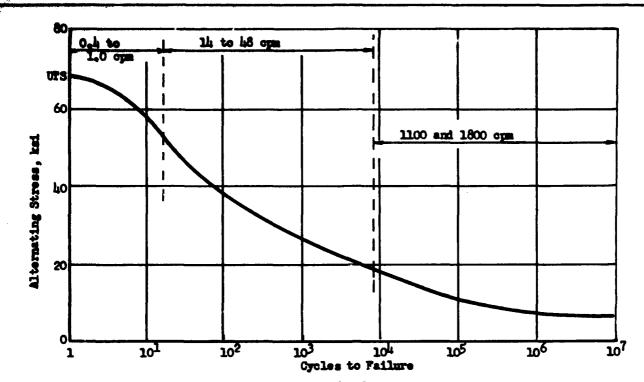
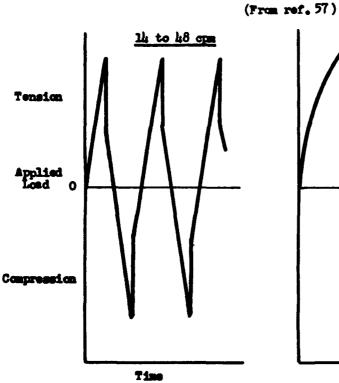


Fig. 105
S-N Curve for 24S-T3, Axial Loads, Fully Reversed at
Three Speeds, on Notched Specimens, Kt = 4.0



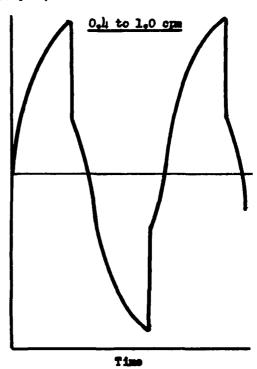
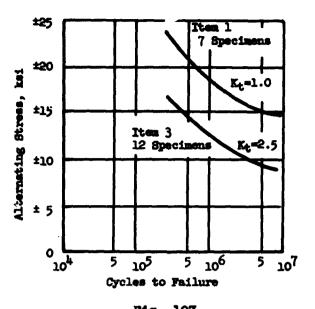


Fig. 106

Typical Load-Time Curves for Part of S-N Curve on Fig. 105

(From ref. 57)

WADD TR 60-42



25±25 Ħ Item 2 Steady Plus Alternating Stress, **20120** 8 Specimens 15±15 Kt=1.0 Item 4 10±10 Specime Kt-2.5 5± 5 0 104 105 5 106 Cycles to Failure

Fig. 107

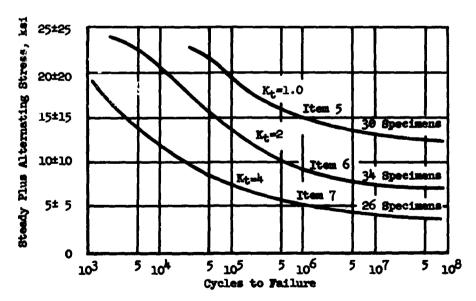
Pig. 108

S-N Curves for 618-T6 Aluminum Alloy.
Fully Reversed Stress (A = ---)

(From Ref. 58)

S-N curves for 618-76 Aluminum Alloy, For Steady Plus Alternating Stress (A = 1.0)

(From Ref. 58)



Pig. 109

S-N Curves for 618-T6 Aluminum Alloy Sheet, For Steady Plus Alternating Stress (A = 1.0).

(From Ref. 45)

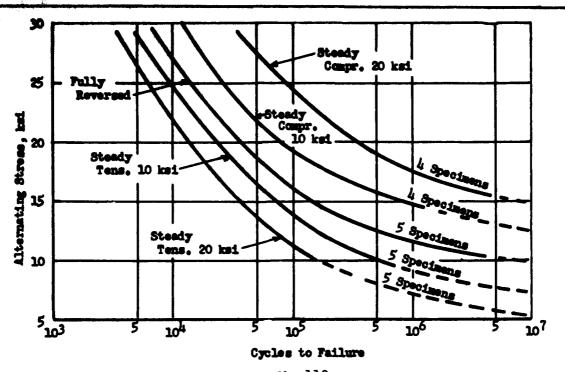


Fig.110
S-N Curves for Alclad 75S-T6, Notched, Kt = 2.5

(From ref. 51)

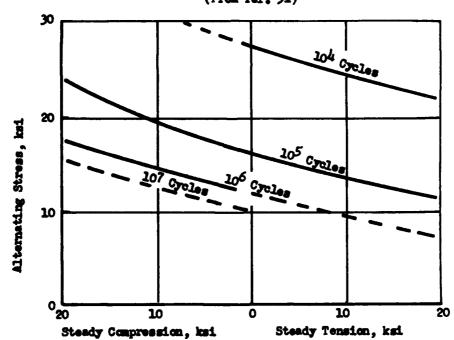


Fig.111

Alternating vs. Steady Stress for Alclad 75S-T6,

Notched, Kt = 2.5

(From ref. 51)

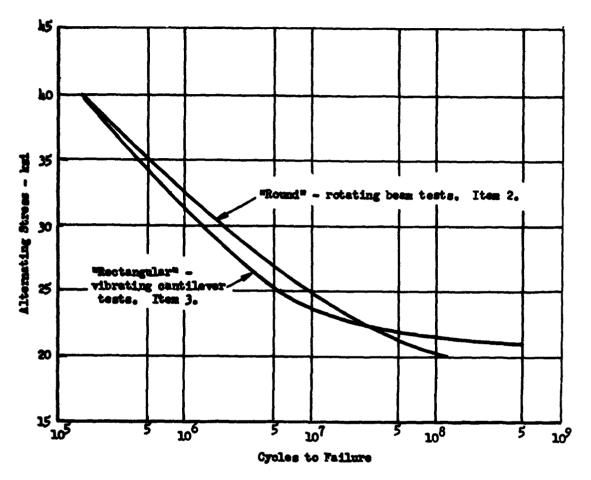


Fig.112

S-N Curves for Aluminum Alloy 75S-T, Extruded, Smooth Specimens

(From ref. 47)

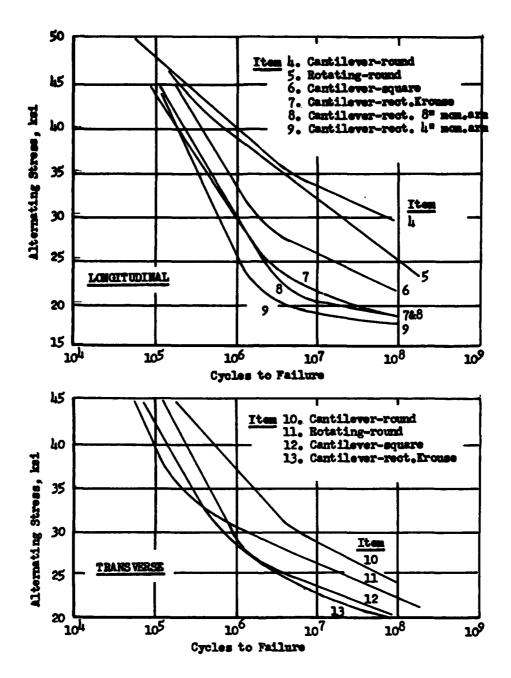
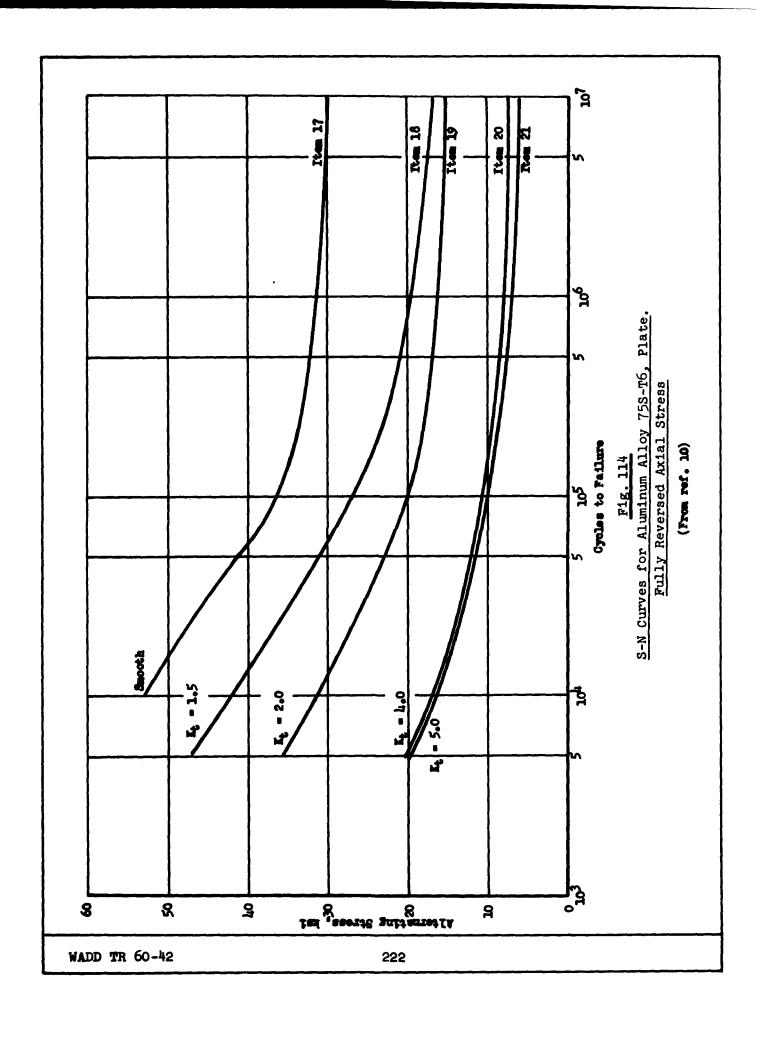
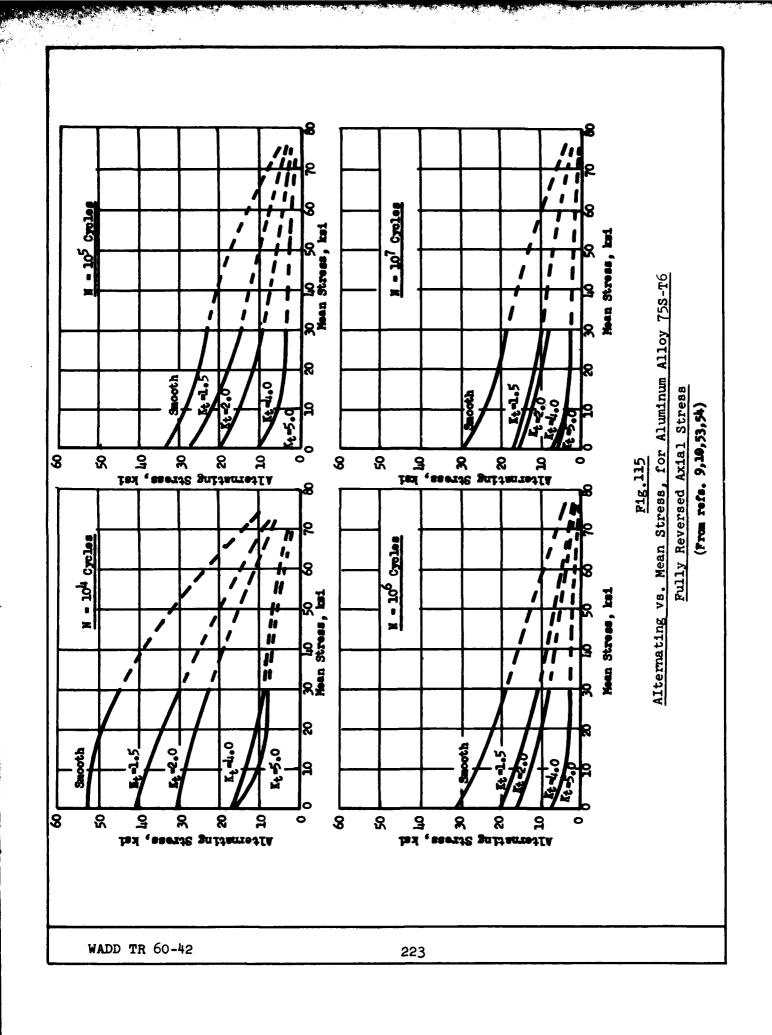


Fig. 113
S-N Curves for Aluminum Alloy 75S-T6, Rolled Plate,
Smooth Specimens.

(From ref. 47)





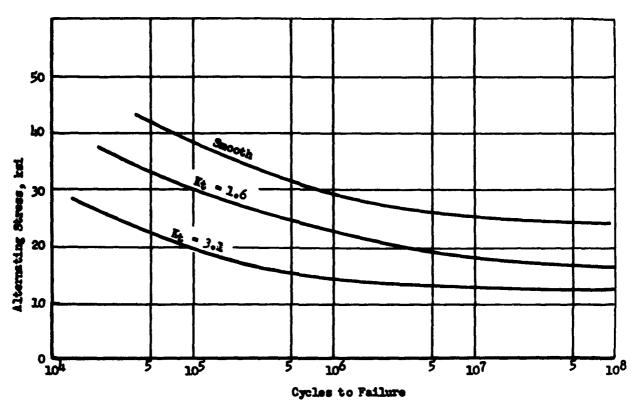


Fig. 116
S-N Curves for 75S-T6 Aluminum Alloy, Hot Rolled
(From ref. 55)

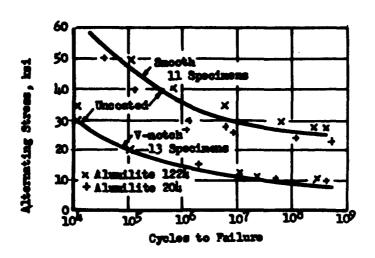


Fig. 117

S-N Curve, 75S-T6 Rolled and Drawn Rod,

Smooth and Notched

(From ref. 59)

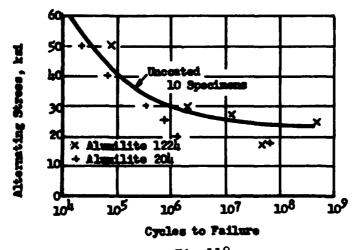


Fig.118

S-N Curve, Extruded Bar 75S-T6,

Smooth

(From ref. 59)

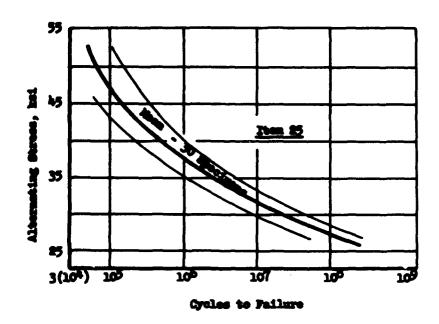


Fig. 119

S-N Curve for 75S-T Aluminum Alloy, Showing Mean, and Scatter Band

(From Ref. 23)

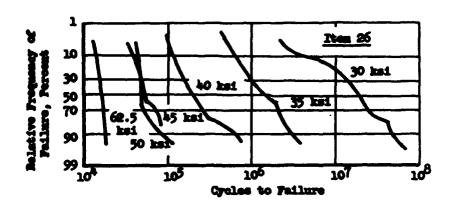


Fig. 120

Log-Probability Diagram Showing Fatigue Life-Times, of Different Stresses, for 75S-To Aluminum Alloy

(From Ref. 60)

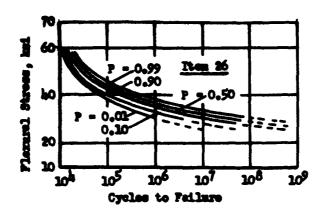


Fig. 121

S-N Curves for 75s-T6 Aluminum Alloy,
for Various Probabilities of Failure.

(From ref. 60)

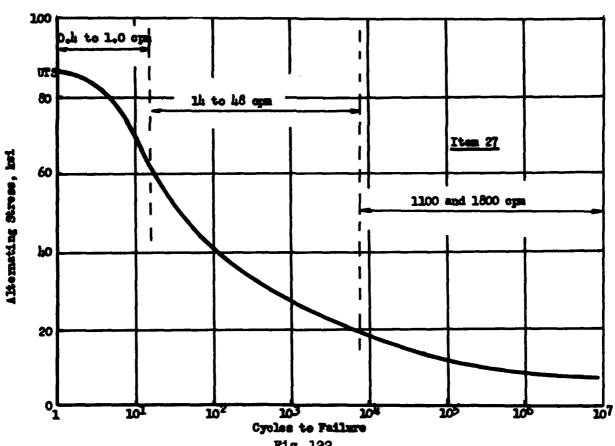
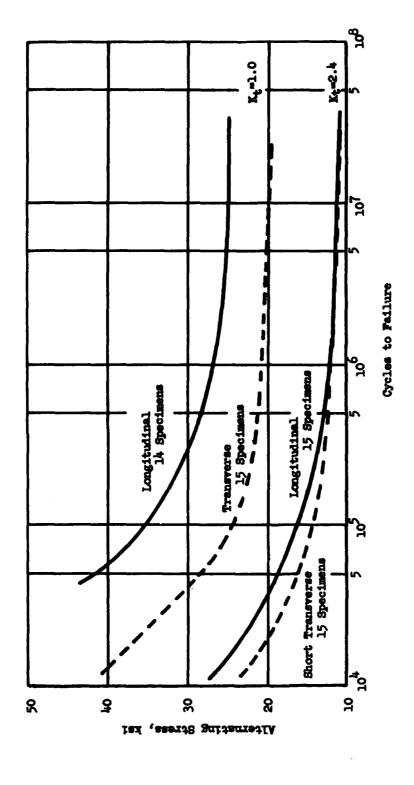


Fig. 122

S-N Curve for 75S-T6 Aluminum Alloy, for Axial Loads,

Fully Reversed, on Notched Specimens. Kt = 4.0

(From ref. 57)



S-N Curves for 7075-76 Aluminum Alloy, Hand Longitudinal, and Short Transverse, Axial (From Ref. 49)

P1g. 123

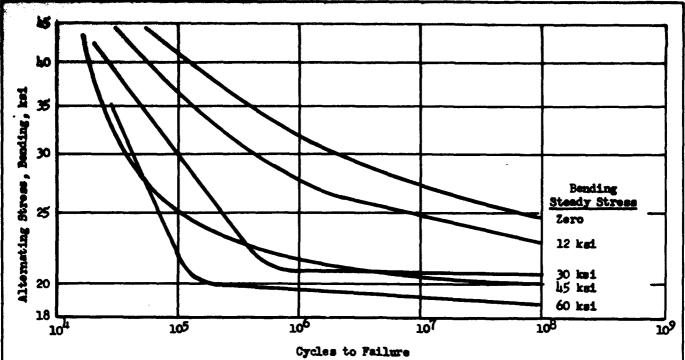


Fig.124

S-N Curves for 76S-T61 Aluminum Alloy-Alternating Bending Stress
Superimposed on the Indicated Steady Bending Stress.

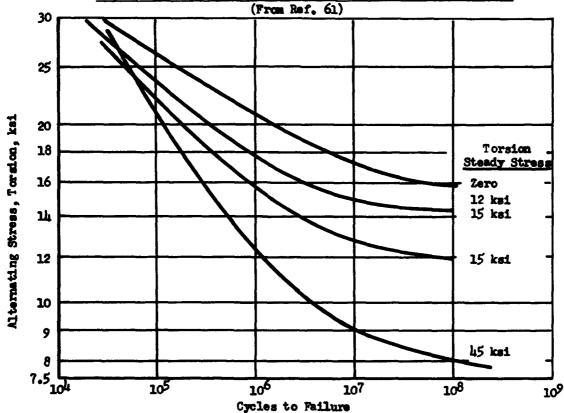
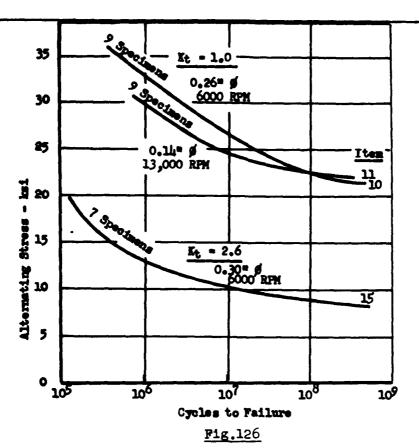


Fig. 125
S-N Curves for 76S-T61 Aluminum Alloy-Alternating Torsion Stress
Superimposed on Steady Torsion Stress.

(From ref. 61)



S-N Curves for Aluminum Alloy X76S-T. Rotating Bending Tests.

(From ref.62)

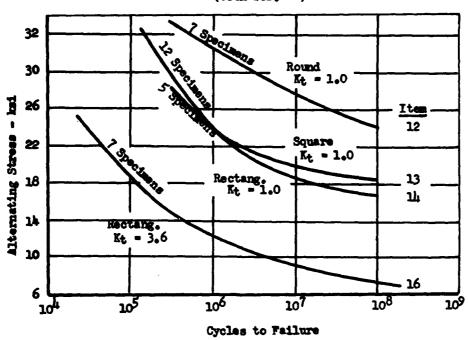


Fig. 127
S-N Curves for Vibratory Reversed Bending of X76S-T Aluminum Alloy
(From ref. 62)

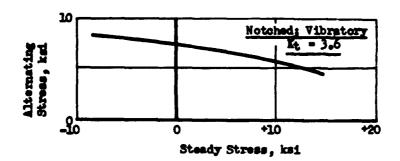


Fig.128

Alternating Stress vs. Steady Stress, for Notched X76S-T Aluminum Alloy. Kt = 3.6

(From ref. 62)

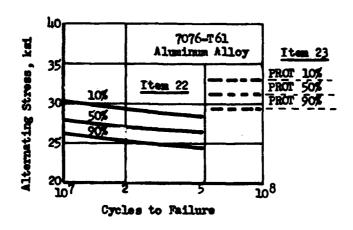
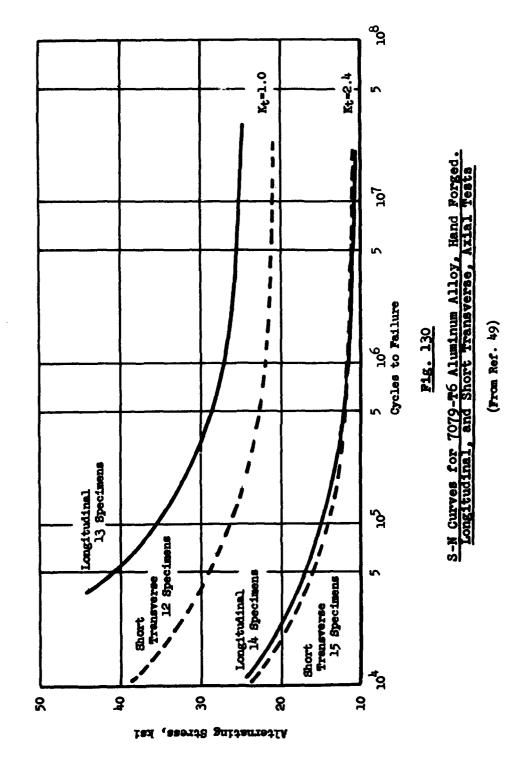


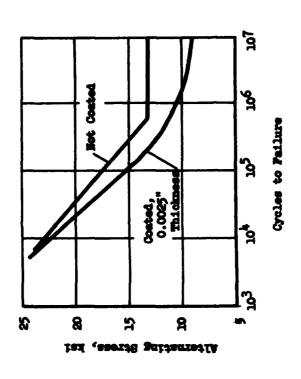
Fig.129

S-N Curves for Aluminum Alloy 7076-T61.

10, 50, and 90% Probability of Survival of Stress at Constant Life

(From ref. 29)





S-N Curves for Magnesium Alloy AZ31X, Not Coated, and Coated Anodically to 0.0025 inch Thickness

8 ref. 63)

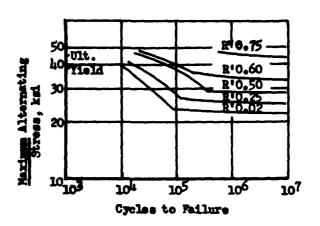


Fig. 132
S-N-R Curves for Magnesium Alloy FS-lh, Smooth.

(Prom ref. 65)

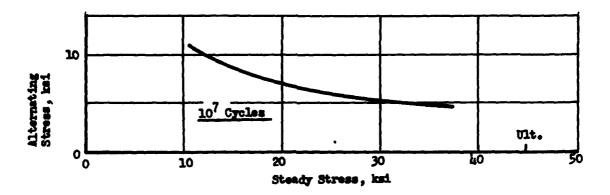
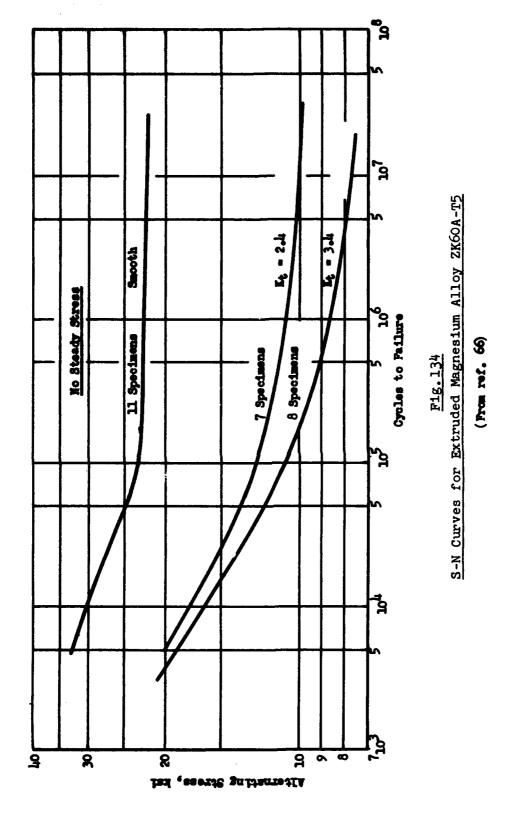


Fig. 133

Steady Stress vs. Alternating Stress for Magnesium

Alloy FS-lh, Smooth Sheet, for N = 10⁷ Cycles.

(Derived from Fig.132)



235

WADD TR 60-42

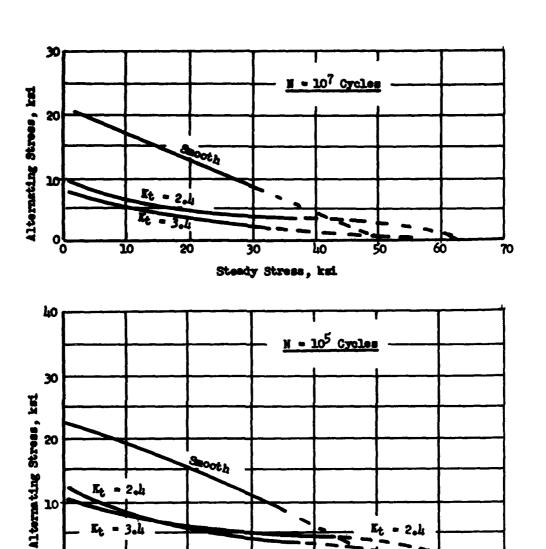


Fig. 135

Alternating Stress vs. Steady Stress for Extruded

Magnesium Alloy ZK60A-T5, for N = 107 and 105 Cycles

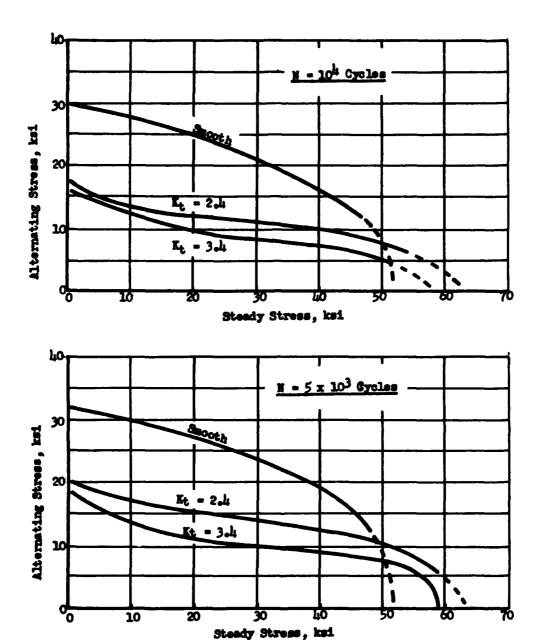
(From ref. 66)

30 40 Steady Stress, ksi

o'r

10

20

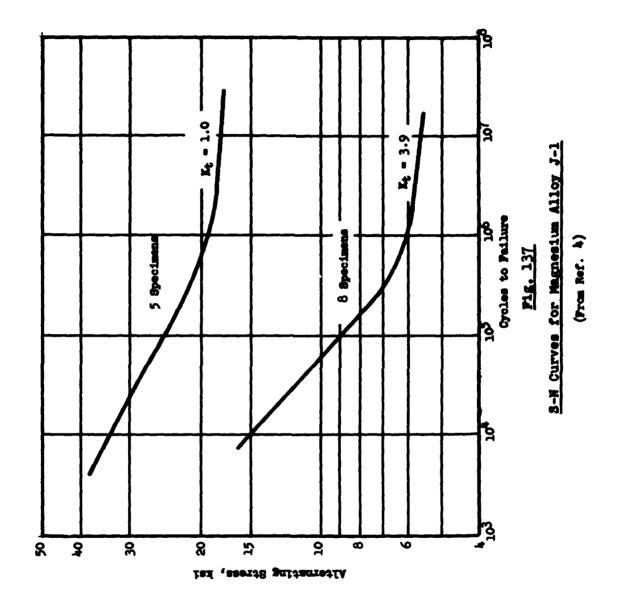


Pig. 136

Alternating Stress vs. Steady Stress for Extruded Magnesium

Alloy ZK60A-T5, for N = 10⁴ and 5(10³) Cycles

(Prom ref. 66)



WADD TR 60-42

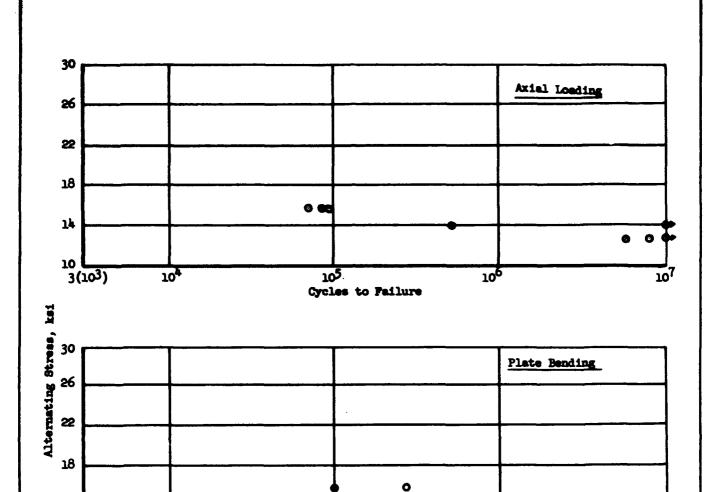


Fig. 138

S-N Plot of Patigue Tests of FS-la (AZ31A-0)

Magnesium Alloy

Cycles to Failure

105

106

107

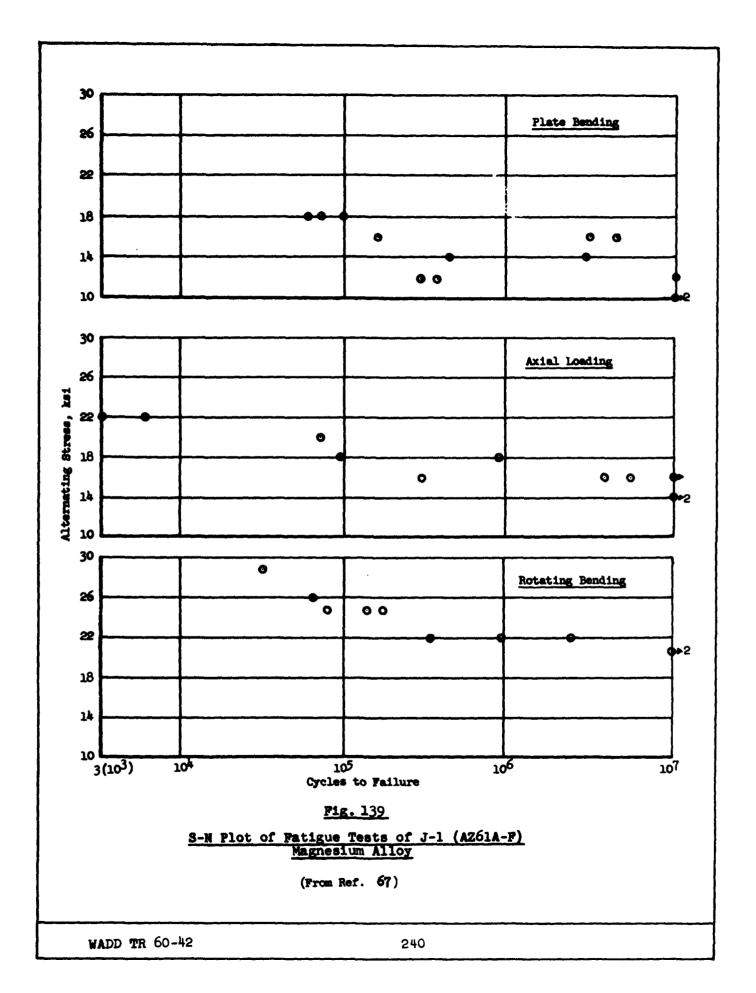
(From Ref. 67)

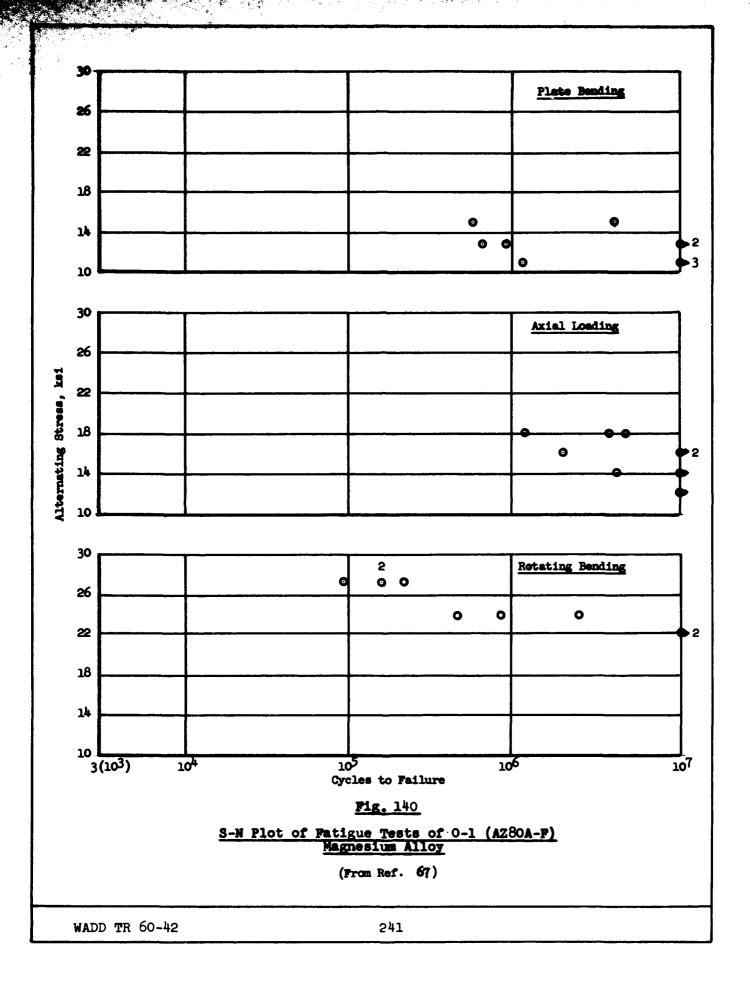
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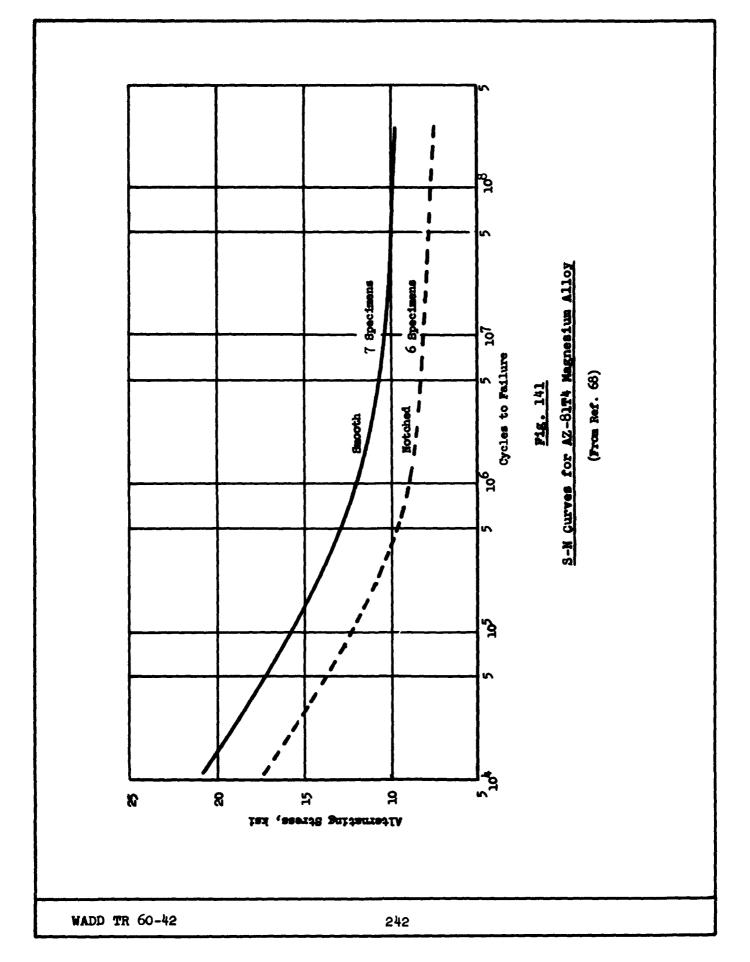
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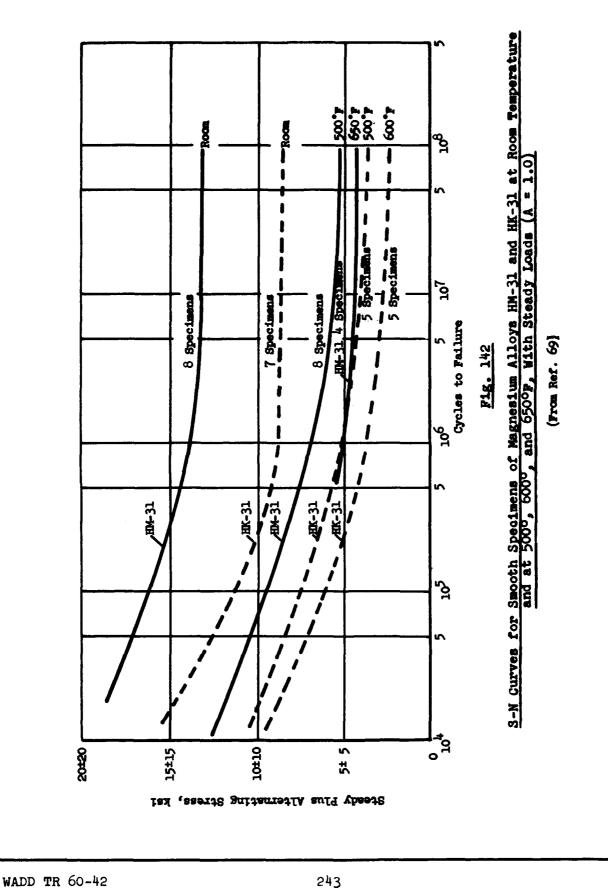
3(103)

104









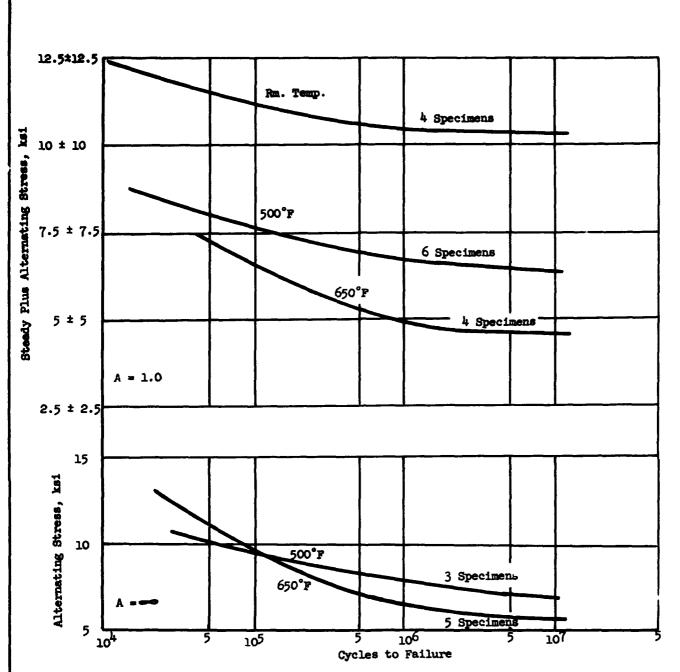
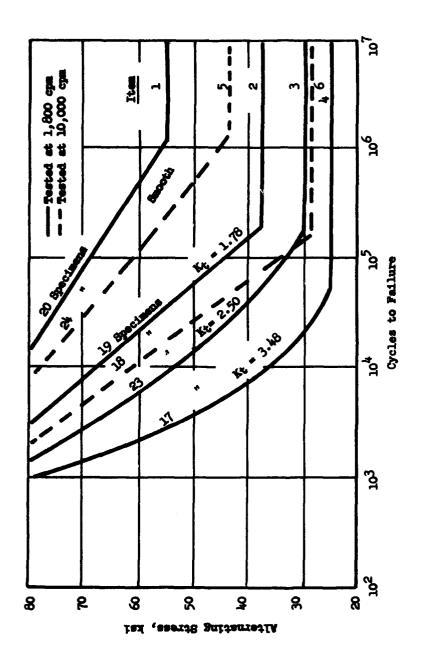
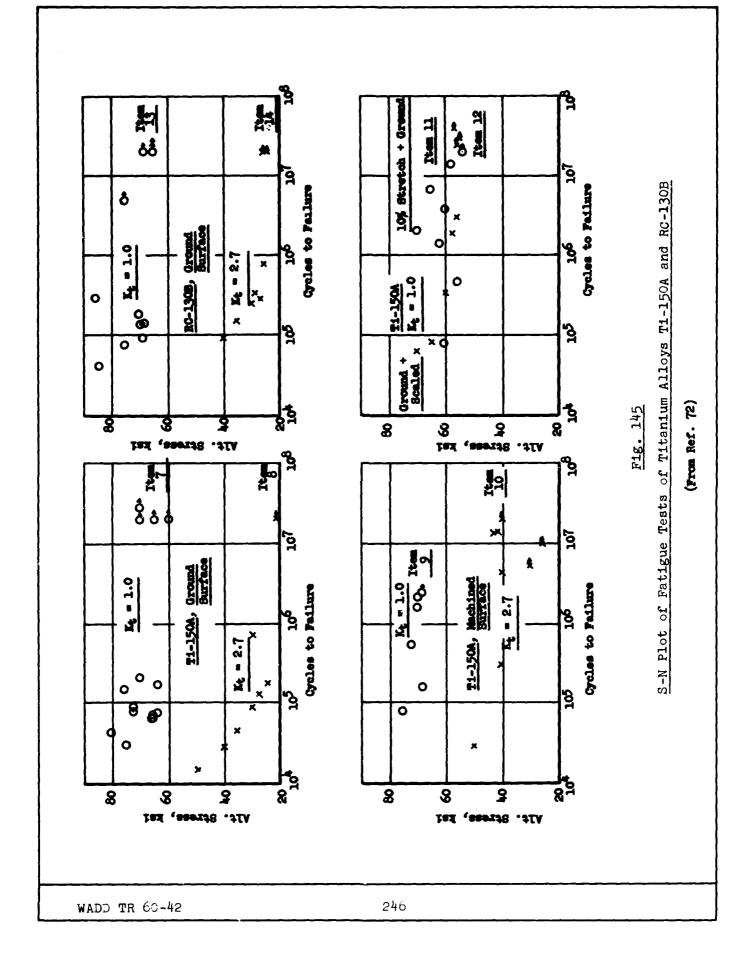


Fig. 143



S-N Curves for Smooth and Notched Specimens of Titanium Alloy, RC 55 Type (From ref. 71)



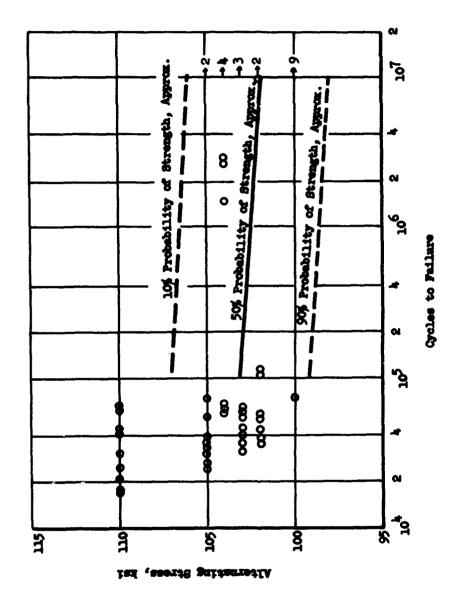
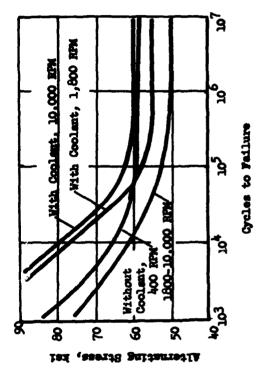


Fig. 146 S-N Curves for Titanium Alloy RC-130B

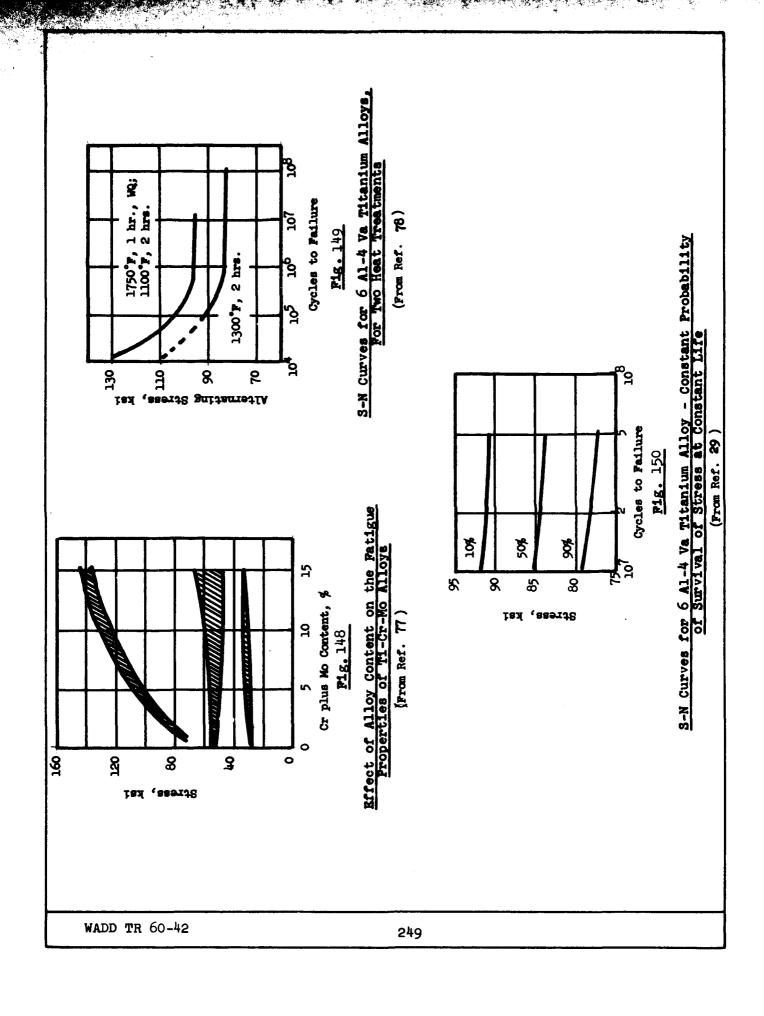
(From Ref. 73)

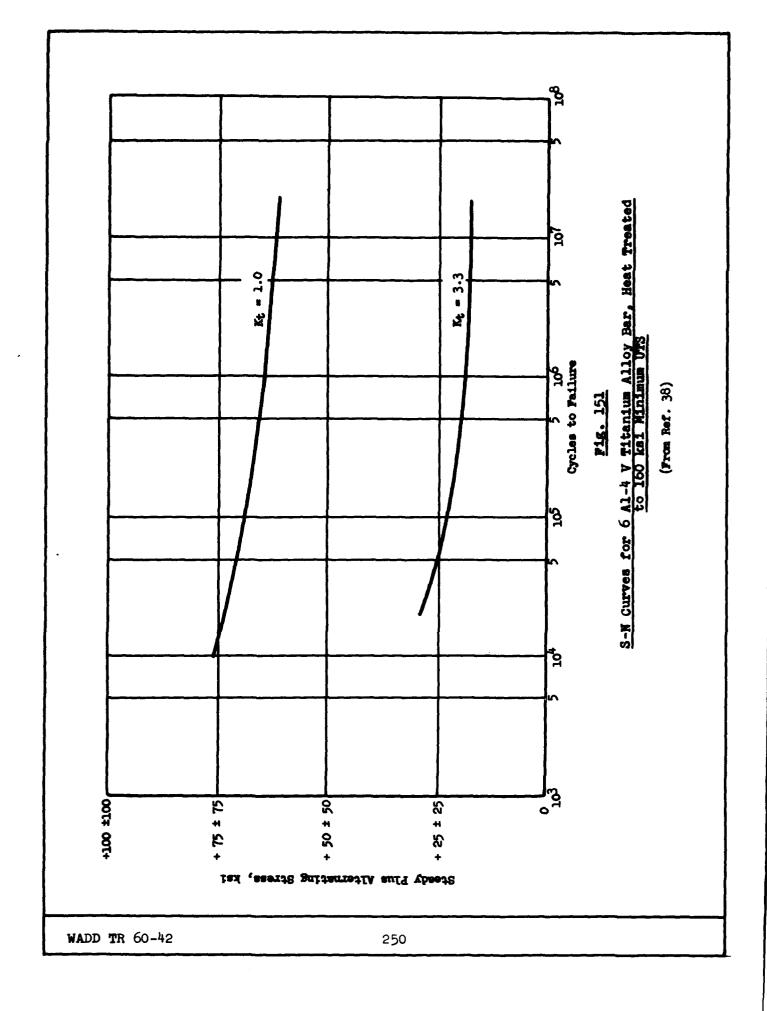


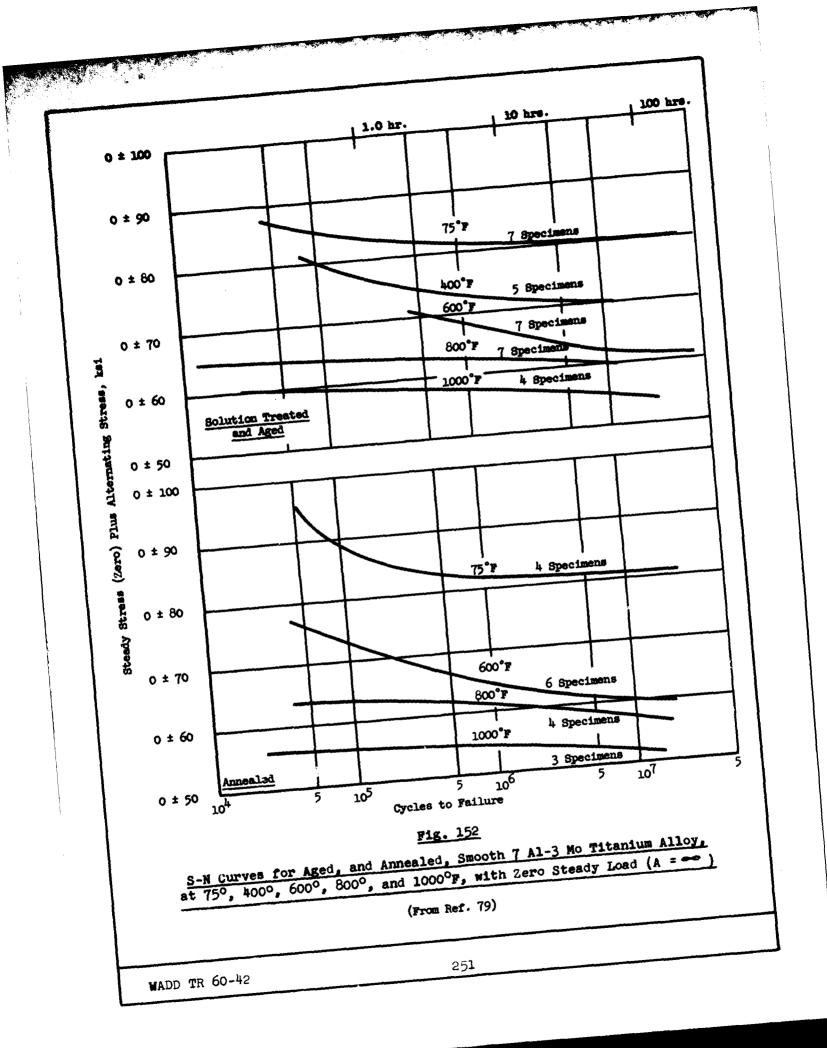
S-N Diagrams for Ti-75A Titanium Alloy
Tested at Different Speeds With and
Without Coolant

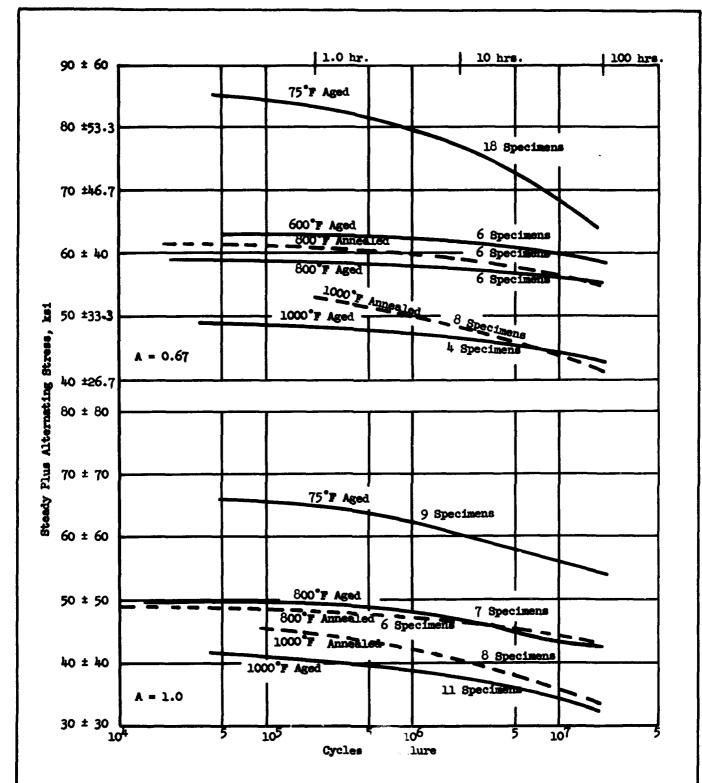
(Prem red. 76)

248







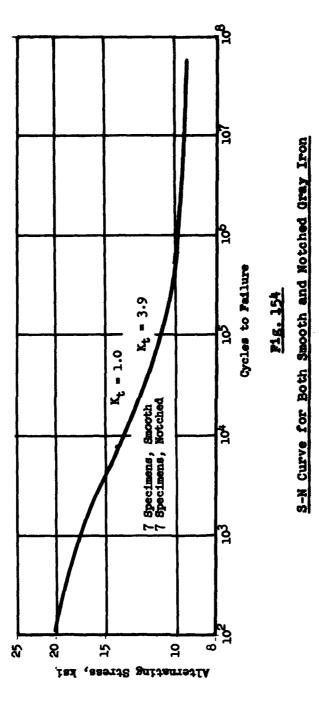


Pig. 153

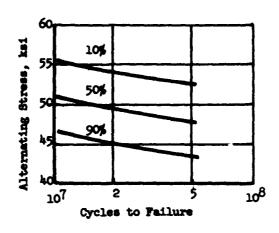
S-N Curves for Aged, and Annealed, Smooth 7 Al-3 Mo Titanium

Alloy at 75°, 400°, 800°, and 1000°F, With Steady Loads (A = 0.67 and 1.0)

(From Ref. 79)



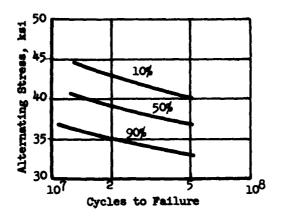
(From Ref. 4)



Pig. 155

S-N Curves of Constant Probability of Survival of Stress at Constant Life. R. R. Moore Tests of Al-N1 Bronse

(From Ref. 29)



F1g. 156

S-N Curves of Constant Probability of Survival of Stress at Constant Life. R. R. Moore Tests of Beryllium Copper

(From Ref. 29)

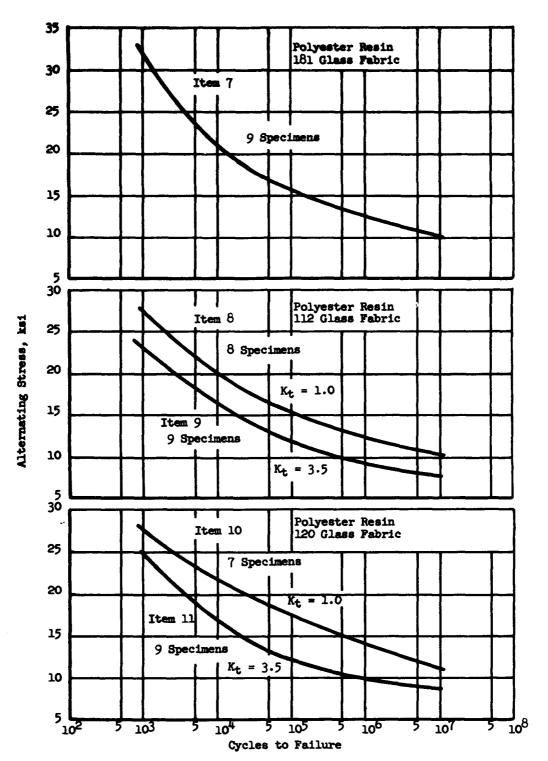
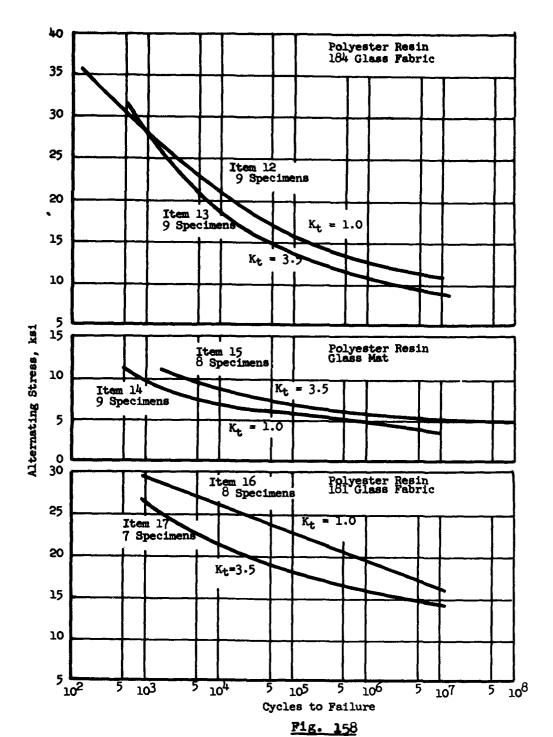


Fig. 157

S-N Curves for Glass-Fiber-Reinforced

Plastic Laminates



S-N Curves for Glass-Fiber-Reinforced Plastic Laminates

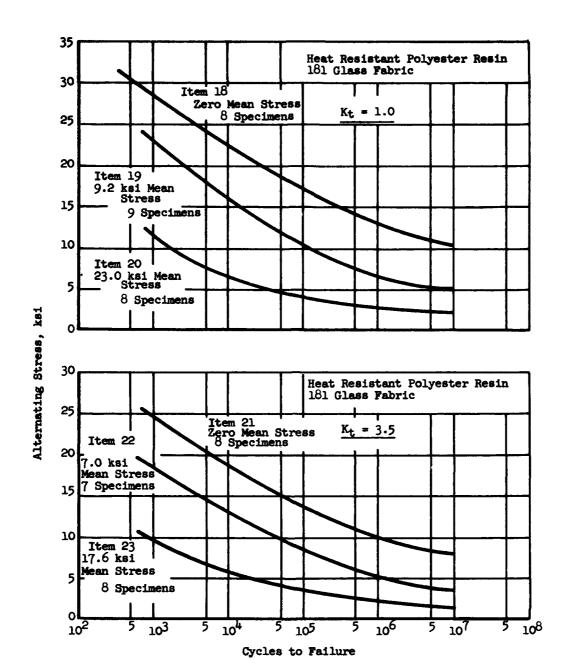


Fig. 159

S-N Curves for a Heat Resistant Glass-Fiber-Reinforced
Plastic Laminate, With and Without Superimposed Mean Stress
(From Ref. 80)

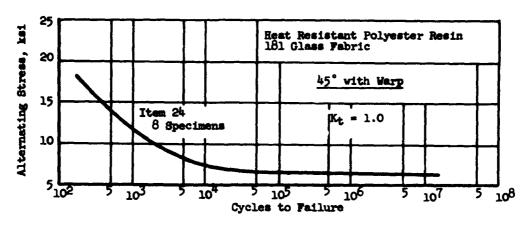


Fig. 160

S-N Curves of a Heat Resistant Glass-Fabric Reinforced Plastic Laminate, at 45° with the Warp

(From Ref. 80)

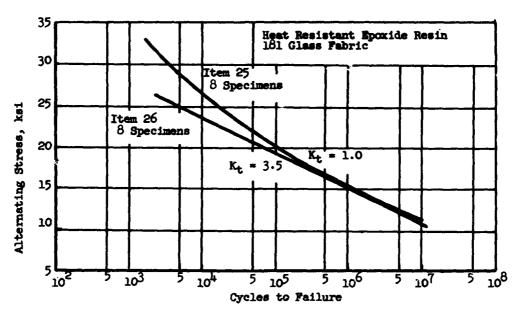


Fig. 161

S-N Curves for a Heat Resistant Glass-Pabric-Reinforced Plastic Laminate

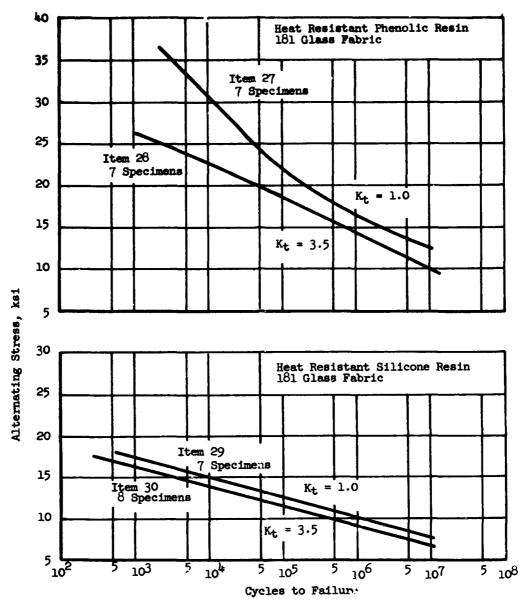


Fig. 162
S-N Curves of Heat Resistant Glass-Fabric
Reinforced Plastic Laminates

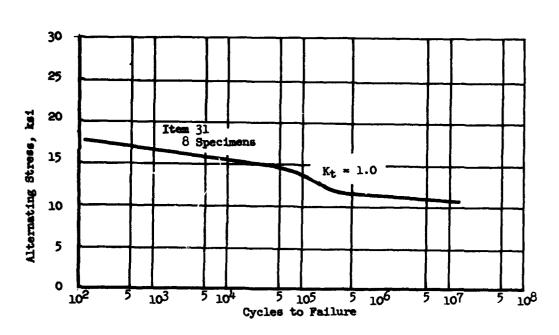
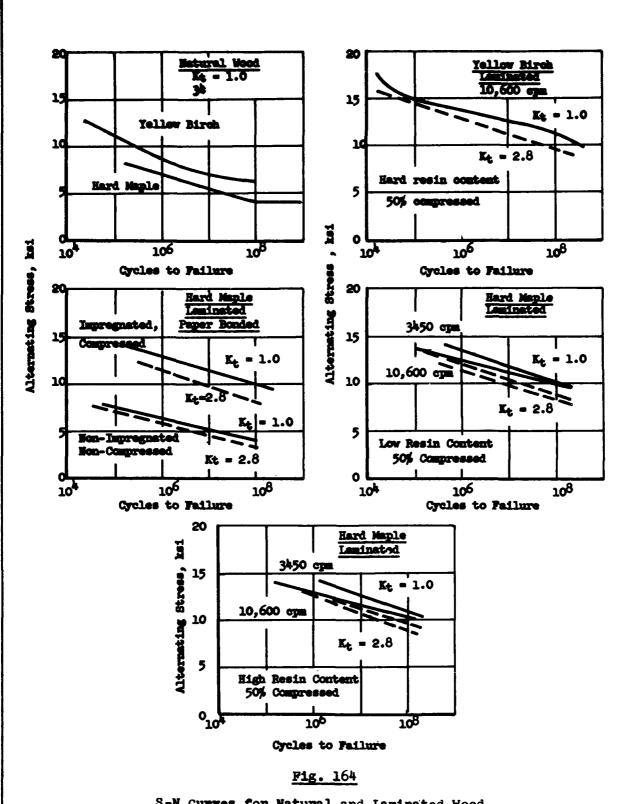


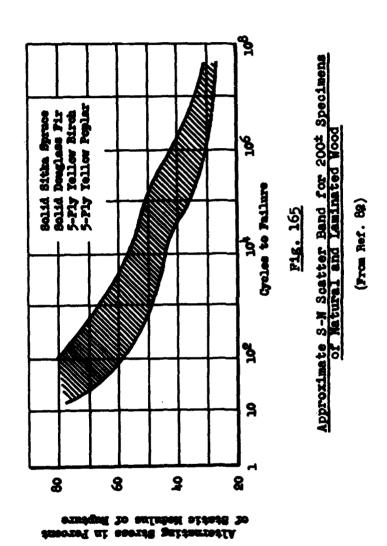
Fig. 163

S-N Curves for a Glass Fabric Laminate Plastic

(Plotted from Table XI of Ref. 42)

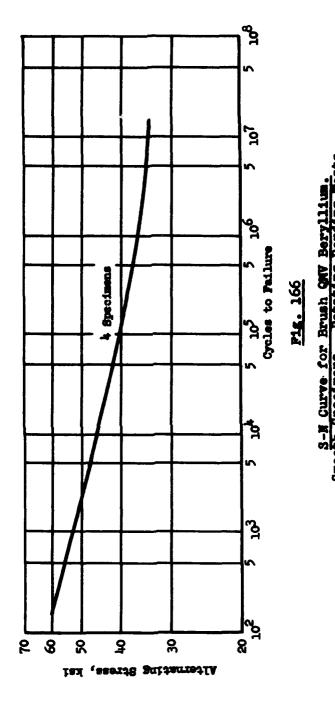


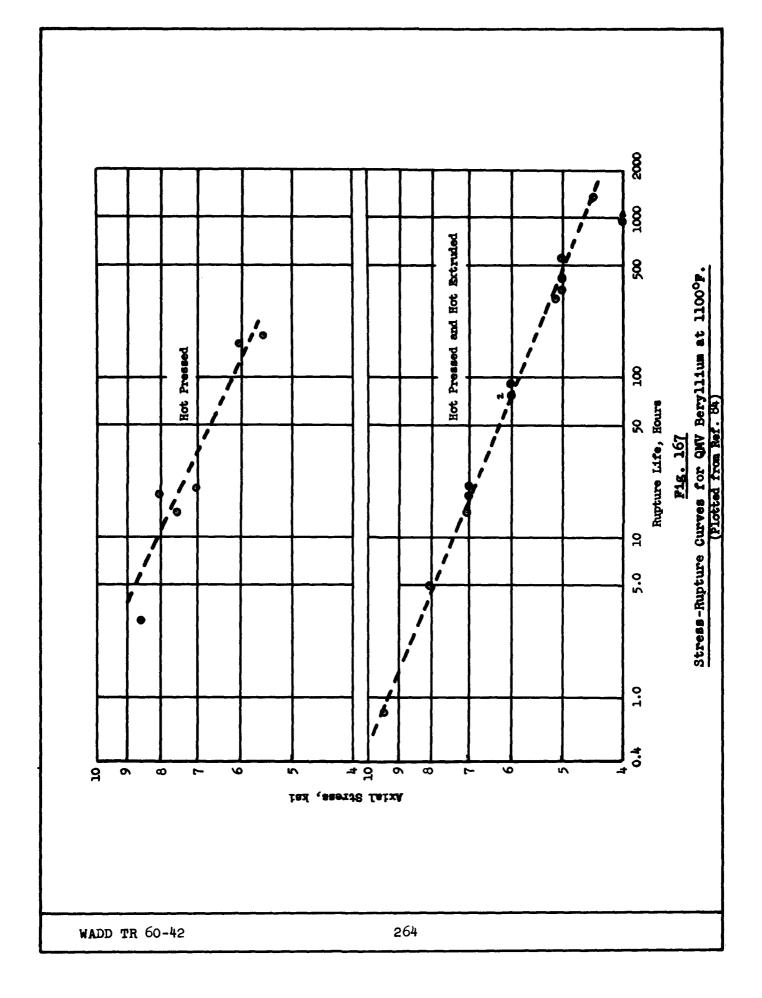
S-N Curves for Natural and Laminated Wood (From Ref. 81)

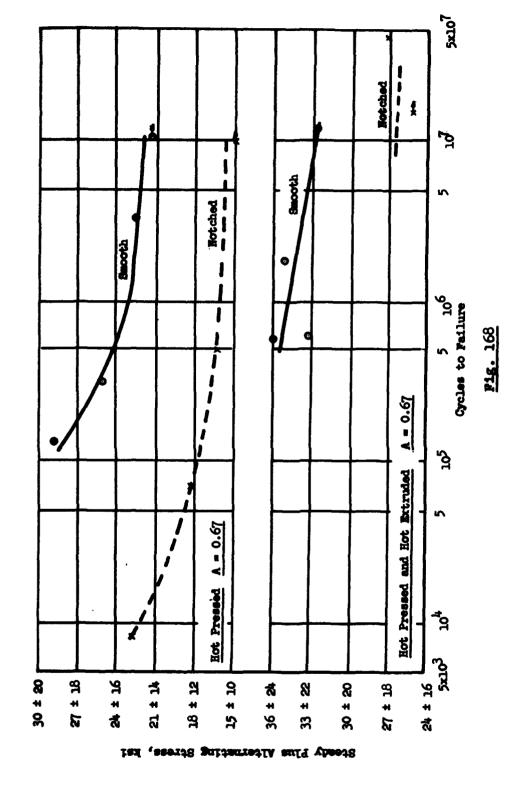


WADD TR 60-42

262

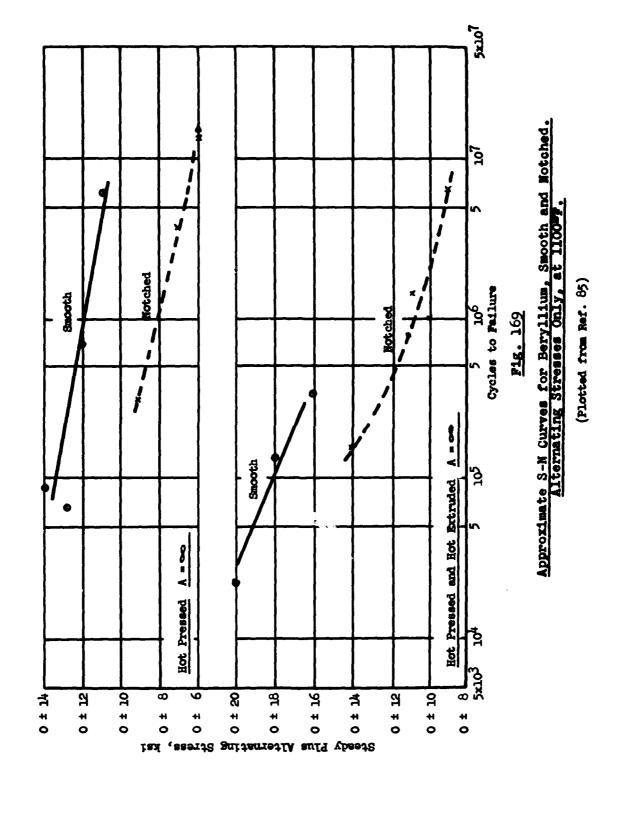






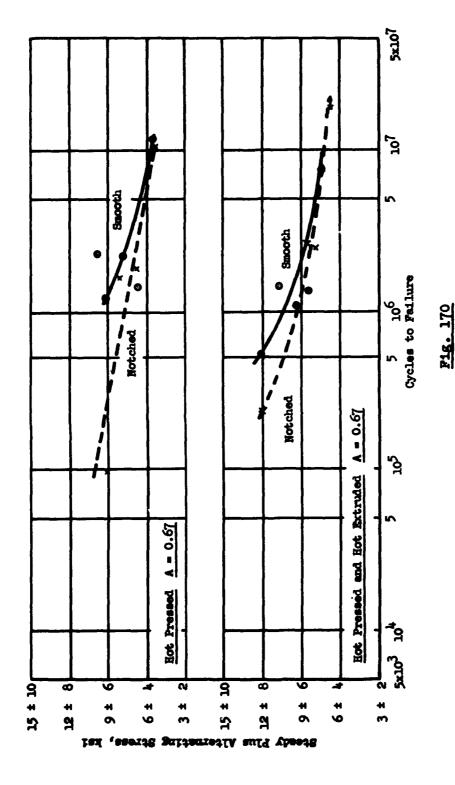
Approximate S-N curves for Beryllium, Smooth and Motched.
Steady Plus Alternating Stress, at Room Temperature.

(Plotted from Ref. 85)



266

WADD TR 60-42



Approximate S-N Curves for Beryllium, Smooth and Notched. Steady plus Alternating Stress, at 11000F.

(Plotted from Ref. 85)

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Bennett, J.A. Beutel, E.	63 70	Horne, G.T. Howard, D.M. Howell, F.M.	51 59
Binns, F.E. Bishop, S.M.	72 9,53,54 48,66	Hyler, W.C.	10,67
Blatherwick, A.A. Boegehold, A.L. Boller, K.H.	48,66 6 80	Illg, W.	57
Briggs, C.W. Brown, W.F., Jr.	5 37	Jackson, L.R.	9,10,53,54,
Brueggeman, W.C.	52	Jaffee, R.I.	65 77
Cers, A.E. Cliet, C.B.	79 50 8	Kessler, H.D. Klier, E.P.	78 13,34
Corten, H.T. Cox, R.J. Crum, R.G.	18 76	Kommers, W.J.	82
Cummings, H.N.	1,27,28,29, 30,35	Landers, C.B. Lazan, B.J.	45 39,40,42,43,
D'Appolonia, E. Demer, L.J. Demmler, A.W., Jr.	71,76 4,39,43 74,75 16	Lipsitt, H.A. Lyon, F.H.	48,66 3 67
Dieter, G.E. Dimoff, T. Dolan, T.J.	8 8,17,23,60, 62	MacGregor, C.W. Marco, S.M. Materials Labor-	55 14,31 84,85
Ebert, L.J.	5	atory, WADD Mehl, R.F. Melcon, M.A.	15,16,21 20
Epremian, E. Evans, E.B.	5 15 5	Mergen, F.C. Muvdi, B.B.	26 13,34
Fairbairn, G.A. Findley, W.N.	38 26,61 18	Neuber, H.	7
Foster, H.W. Found, G.H. Fuller, F.B.	64 81	Oberg, T.T. Ogden, H.R.	24,47,81 77
Gatts, R.R. Grossman, N.	14,31 55	Podnicks, E.R.	42
Grover, H.J.	9,10,32,53, 54,65	Ransom. J.T. Richart, F.E., Jr. Romualdi, J.P.	21 23 71
Hanley, B.C. Hardrath, H.F.	17 45,57	Rooney, R.J. Rosenberg, A.H. Rosenthal, D.	i1,46,47 26 58

LIST OF AUTHORS OF REFERENCES (Continued)

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Sachs, G. Schulte, W.C.	13,34,37 27,28,29,30,
Schwartz, D.C. Schwartz, R.T. Sell, R. Sherman, R.G. Sinclair, G.M. Sines, G. Sinnott, M.J. Smith, F.C. Starkey, W.L. Stewart, J.M. Stickley, G.W. Stulen, F.B.	25 25 37 78 60 58 74,75 52
Tarasov, L.P. Thomassen, L. Toolin, P.R. Torvik, P.J.	23,32 74,75 44 83
Trapp, W.J.	22
Utley, E.C., Jr.	45
Vitovec, F.H.	36,40,41
Wallgren, G. Wang, D.Y. Ward, E.J. Ward, M.V. Wells, N.J. Wilks, I.E. Work, C.E.	56 49 24,25 19 19 51 23

LIST OF MATERIALS

MATERIAL	TABLE	items	PARAGRAPH	PIGS.
Steels and Heat Resistant Alloys				
1008	Ţ	1-3	2.2.1	2 3
1020		4-5		. 3_
1040	11	6-13	11	4-7
1330	11	14-19	1) 11	~~~
1340	11	20-23	"	0.55
2315	11	24-33	tt ti	8-10
2330	n	34-37	85	11-12
2340	11	38-3 <u>9</u>	11	13
4130	et	40-44	ti	14-15
4135	91 11	45-48	11	
4140	**	49-52	ri	16
4320	n	53-59	11	
4330	. 11	60 - 73	11	17-21
4335		74-77	0 0 0	22-46
4340	II	1-85	2.2.2	47
4350		86-95		48-50
52100	ΙΙΪ	1-32 33-36	2.2.3	51-52
8630	11	33-30 37-40	П	53-54
8640	n	41-42	11	55
14850	11	43-52	n	56-60
98840	IA	10-11	2.2.4	62
Crue. UHS -260		1-4	3,2	66
Ferrovac (WB-49)	Ÿ,	5-6	J _H -	67
OMR-235 H-11		10-11	11	62 66 67 68
H-23	11	12	77	69
Halmo	11	7	11	
Hastalloy	n	8-9	14	67
Hy-Tuf	IV	14-15	2.2.4	64
Incomel 7130	v	17-26	3.2	73,74
Inconel X	11	13-14	11	70,71
Inconel X-550	27	15-16	31	72
Lapalloy	£f.	27 28	et	75
M-1	#		n .	
M-10	11	30-33	11 11	76
M-30C	n	See Tricent	17	61
MV-1	n	29	n	
n-155	π	34-35	n "	70
Refractalloy	1) 11	40-45	n	79
Rene 41	•	91-102		ογ,00, 89
s-816	n	46-63	11	87,88, 89 70,75,
Sandvik	n	64-67	11	81
Stainless 347	n	68-70	n	82
Stainless 403	n	71-77	11	70,75 , 83
Chainles 17-7 DU	n	38-39	79	78
Stainless 17-7 PH Stainless PH-15-7 Mo	tt	36-37	Ħ	77
Stellite	Ħ	(See X-40)	ft	84
Super Hy-Tuf	ĮV	9,16-17	2.2.4	78 77 84 65 63
Super TM-2	Ħ,	12-13	n -	63
Ambau 011 p				-

LIST OF MATERIALS (Continued)

MATERIAL	TABLE	ITEMS	PARAGRAPH	FIGS.
Steels and Heat Resistant Alloys (Continued)				
Timken 16-25-6 Tricent TP-2-B TP-2-R Udimet 500 Waspalloy WB-49 X-40	V IV ""	81-83 1-8 84 85 86-87 88-90 See Ferrovac 78-80	3.2 2.2.4 3.2 "	86 61 70 70 67 85 66 84
Aluminum Alloys				
2014 2024 6061 7075 7076 7079	VI VIII VX X X X	1-10 1-24 1-7 1-31 1-23	4.2.1 4.2.3 4.2.4 4.2.5 4.2.6	90-93 94-106 107-109 110-123 124-129 130
Magnesium Alloys				
AZ-31A-0 AZ31X AZ61A-F AZ80A-F AZ81-T4 C-AC C-HT C-HTA C-HTS FS-1 FS-1a FS-1h 1FS-1h 1HK-31 HM-21 HM-21 HM-31 J-1 0-1 ZK60A-T5	XII	See RS-la 1-19 See J-1 See O-1 62,63 33,37,41 30,34,39 31,36,40,42,43 32,35,38 27-29 20-26,54,55 See AZ31X 44-48 67-69 70-74 64-66 52,53,56-58 59-61 49-51	5.2 "" "" "" "" "" "" "" "" "" "" "" "" ""	138 131 141 138 132,133 142 143 142 137,139 140 134-136
Titanium Alloys				
"Commercial" Rc-A-30314	XIII	45-50 35-40	6.2	
WADD TR 60-42		277		

LIST OF MATERIALS (Continued)

MATERIAL	Table	items	PARAGRA PH	FIGS.
Titanium Alloys (Continued)				
Rc-130B Rc-55 T1-75A T1-150A T1-2.5 Cr-2.5 Mo T1-7.5 Cr-7.5 Mo 6 A1-4 Va 7 A1-3 Mo	XIII	13-15,24-34 1-6 16-23,41-44 7-12 55-62 51-54 63-66 67-86	6.2 n n n n	145-146 144 147 145 148 148 149-151 152-153
Miscellaneous Materials				
Al-Ni Bronze Beryllium Beryllium Copper Glass Fiber Plastic Lam. Gray Iron Ingot Iron Wood and Plywood	XIV n n n	50-63 6 7-31 3-4 1-2 32-49	7 . 2 n n n n n	155 166-170 156 157-163 154 164-165

UNCLASSIFIED	UNCLASSIFIED UNCLASSIFIED UNCLASSIFIED
CURTISS-WRIGHT CORPORATION, Calchell, F. J. SONE GUARTIATIVE ASPECTS OF PATIGUE OF MATERIALS, by H. M. Cummings, March 1960. 2780. Incl. figs. and tables. (Froject 7781; Task 73810) (Wand R 60-42) (Contract AF 33(616)-6552) Uncleasified report In this report are given not only the fatigue properties of many structural materials but also the "statio" properties and such other supplementary information as we given in the references consulted. The data is in general from room temperature tests, but some is given on tests at higher temperatures. The data is presented in tables and on ourses, supplemented by brief discussions in the text.	
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CURTISS-WRIGHT CORPORATION, Caldwall, F. J. SOME GUARTITATIVE ASPECTS OF PATIGUE OF MATE- RIALS, by H. H. Cummings, March 1960, 278p. Jacl. figs. and tables. (Project 7381; Task 73810) (Wand R. 60-42) (Contract AF 33(616)-6552) Unclassified report In this report are given not only the fetigue properties of many structural mate- rials but also the "static" properties and such other supplementary information as was given in the references consulted. The data is in general from room temperature tests, but some is given on tests at higher tempera- tures. The data is presented in tables and on curves, supplemented by brist discussions in the taxt.	